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PROSPECTS FOR DEVELOPING SUPERCRITICAL PRESSURE GENERATING UNITS

40130006a Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 8, 5 Aug 87 pp 1-3

[Article by Liu Renchai [0491 4771 5436] of the China Electrical Engineering Society]

[Text] The China Electrical Engineering Society convened a Scholarly Conference on Supercritical Pressure Generating Units in late April 1987. Preparations for the conference were made by the S&T Information Institute in the Ministry of Water Resources and Electric Power, which invited the more representative of comrades familiar with research on supercritical pressure generating units to participate. Nearly a year was spent in preparation for the conference, during a time when China was importing supercritical generating units from the Soviet Union and western countries, so the meeting was extremely rich in content. It included in-depth analysis of information from foreign countries, technical and economic research concerning the development of supercritical generating units in China, an introduction to the situation in importing supercritical generating units from foreign countries and plans for production within China, as well as research reports concerning thermal systems, thermal stress, reduction of useful life, intensified heat transfer and other topics related to supercritical generating units. Discussions flowed freely during the conference and there was a full exchange of opinions that played a far-reaching role in mutual complementation and concentrating thought and led to relatively identical opinions concerning the prospects for developing supercritical generating units in China. This article will discuss some of the main issues and describe some related proposals.

1. The Necessity of Developing Supercritical Generating Units

China has experienced power shortages for a long time and it has become so serious as to attract attention throughout the country. Forecasts indicate that electricity output in China must at least quadruple between 1980 and 2000 and that it must again double to more than 480 million kW between 2000 and 2015. Of this amount, more than two-thirds (over 70 percent of the power output) is to come from coal-fired thermal power. Furthermore, many factors restrict the rate of growth in primary energy resources in China. Although the situation has improved slightly at present, long-term shortages will persist and there is not enough capital to make up for them. Inadequate capital,

coal shortages and the need for rapid growth in coal-fired power certainly will demand scientific and technical solutions.

If one looks at the history of coal-fired power, coal-fired technologies have made progress only in the areas of improved steam parameters and higher single unit capacity. At the same time, investments per kW have declined and the amount of coal consumed per kWh also has declined. Are there limits to economic benefits from increased parameters, and are there any other methods? During the 1950's, some of the industrially advanced nations, particularly the United States, began an attack on 306 to 357 kgf/cm^2 supercritical parameters, but the anticipated results were never attained. It was also during the 1950's that magnetohydrodynamic generation [MHD] first appeared, and many countries placed their hopes on MHD. Breakthroughs came hard, however, even after some time, so a few countries abandoned it. Later, during the oil embargo, some countries were forced to promote advanced coal burning technologies and develop fluidized-bed or integrated coal gasification cycles, fuel cells and other methods to increase thermal efficiency. Nevertheless, these new things were not easy to accomplish. By the 1980's, they had returned in a renewed attempt to use their minds concerning supercritical generating units. More than 30 years have passed since the failures of the 1950's, and it may be possible for technical advances in the past three decades to permit some of the past technical obstacles to be overcome.

Based on the actual situation in China, additional improvements in the economy of power generation should involve utilization of more large capacity generators and increased steam volumes and flow rates in large units. This requires the adoption of even higher steam parameters, so, with the exception of the need for good work to import subcritical 300 MW and 600 MW generating units, a one-grade increase in steam parameters to the supercritical 245 kgf/cm^2 may be more realistic than other routes to increase thermal efficiency. Currently, the Huaneng International Electric Power Development Company is cooperating with Shanghai Municipality to adopt a program to import the first two supercritical generating units for the Shidongkou No. 2 Power Plant and to manufacture the next two units in China, which would move supercritical generator work in China substantially ahead of schedule. The plan is to put supercritical generating units developed in China into operational testing and to confirm their forecast feasibility and economy during the 1990's. Moreover, manufacturing costs will be rational and they will have entered a mature stage, so the selection of supercritical generating units for use in power grids on the basis of concrete conditions after 2000 as well as a gradual increase in the proportion of these generators in conjunction with gradual progress toward higher parameters will lead to further increases in their thermal efficiency. In the absence of new breakthroughs in new technologies for coal-fired power generation, this route will be unavoidable.

II. The Situation in Foreign Countries

To develop these new technologies first of all requires borrowing from the experiences of foreign countries. Many comrades have done very profound analytical research on the situations, problems, lessons and experiences of foreign nations in developing supercritical generating units. Some time ago,

there were doubts about questions of availability rates of supercritical generating units in the United States. This time, however, the more complete work everyone has done permitted relative agreement concerning availability rates, efficiency, manufacturing costs and other issues of supercritical generating units compared with subcritical units. The view is that the availability rates of supercritical generating units would be no lower after improvement than those of subcritical units, that their thermal efficiency would be 1 to 2.5 percent higher than subcritical generating units, and that the cost of building a supercritical generator power plant would be 2 to 5 percent higher than with subcritical units. Some have suggested that it would be only 0.7 percent higher.

While analyzing the experiences and lessons of various countries, it was felt that Japan's successful experiences in developing supercritical generating units deserved attention. Because of the government lead, joint efforts at cooperation by all the manufacturing plants and electric power companies have permitted the work to be carried out in a planned and organized fashion. There is a solid technical foundation and the levels of manufacturing and operation are rather good. The materials industry is very strong. They burn superior quality oil and gas fuels, which makes it rather easy to attain higher boiler availability rates and efficiency. The manufacturing industry is concerned with opening up overseas markets and gaining victory through quality.

III. Evaluation of Economic Results

The goal of developing supercritical generating units is to obtain economic benefits. A price must be paid for any type of technological advance, so while steam parameters and thermal efficiency would be higher, so would the manufacturing costs. When income is relatively low, then there must be a net profit before they can stand on firm ground, which is required by social progress. It is not easy to move up to the stage of supercritical generating units, and thoughts of a major jump are not possible. A move up to the lowest stage of supercriticality at only 245 kgf/cm^2 and 538°C/538°C would not be very economical, but neither would the increase in manufacturing costs be very great. During the discussions, several comrades made some precise analytical calculations. The results were rather scattered, but the majority felt that the price of coal in China is too low, and that under conditions in which the principal and interest on investments must be repaid, an increase of slightly more than 1 percent in efficiency is not that economical when compared with the added cost of early investments. In the long term, however, a rational readjustment in the overly cheap price of coal will be necessary. Moreover, to attain advanced supercritical technologies with even greater economic results, it will be necessary to pass through low level stages in supercritical technologies. For this reason, it was felt that economic analyses can employ established data from other countries and that more attention should be placed on additional developments of economic results. Of course, there was some debate concerning this point. An example is the question of why Western Europe never developed supercritical generating units. With the exception of France, where the reason is that they are only developing nuclear power and do not intend to develop additional thermal power, doubts remained in the other cases concerning economic results of mature

low-level supercritical generating units and the feeling was that traditional subcritical generating units are more stable. This also is the view of some comrades in China.

IV. Dealing Properly With the Relationship Between Existing Supercritical and Subcritical Generating Units and the Development of Supercritical Technologies

This issue concerns everyone the most and has aroused the most heated discussions. The question of how the quantity and quality of power generation equipment can satisfy the development needs of the electric power industry has been the focus of debate for many years. The problem was not very big with 100 MW generators, but there were several discussions later concerning 125 MW, 200 MW and 300 MW generating units, and many perfected measures were arranged for them. Hopes now are being placed on importing 300 MW and 600 MW units from the United States, but the timing and manufacturing costs are not ideal, which has affected additional orders, and in turn has affected the manufacturing costs. These problems have not been solved, so the fact that everyone is worried about supercritical units again is understandable.

The generators installed in a power grid are there to produce electricity, and user indices are more important than heat consumption indices. This means especially that they demand quality and they demand reliability. An improvement in the national power shortage before the year 2000 will require high-pressure 200 MW and subcritical 300 MW and 600 MW generating units. Assuring good quality of these generating units and making further reductions in their manufacturing costs are the two most important and urgent tasks we face. The achievements made in placing the 200 MW generating units into operation have not been bad, but there are major hidden dangers. Bearing stability is poor, the safety of the intermediate short-axles is not adequate and they may cause occasional serious accidents. The Dongfang Steam Turbine Plant's 300 MW generating units have 1-meter-long vanes that must be tested and the 300 MW and 600 MW units being imported must be placed into operation before they can be understood clearly. A great deal of work must be done to digest, absorb, and utilize Chinese-made materials to reduce manufacturing costs further. The failure of manufacturing costs to come down also is problematic and opinions are very sharply drawn.

Although it can be said that availability rates of supercritical generating units are comparable to subcritical units, they actually are the result of efforts in the United States made over the past 20 years. As parameters increase, the difficulty also increases, as do the number of problems and quality requirements, and there also is a greater need to be able to do good work with subcritical generating units as a foundation before it will be possible to step up to the level of supercritical generating units. This means that if problems with subcritical generating units are not resolved, it is hard to imagine that supercritical generating units can be handled well. For this reason, whether one is concerned with technology or with the urgent demands placed on the electric power industry, actions first must be taken to deal with problems in subcritical generating units before the conditions will exist for development of supercritical units. Of course, there are no

limits to the work, which means that if we wish to wait on supercriticality until no work remains to be done with subcriticality before taking up supercriticality again, there could be a great deal of redundancy. If a redundant deployment of forces must embody the focus, then the development of supercritical units must not affect progress and quality in the digestion and absorption of subcritical technologies. Comrades in electric power departments are particularly concerned about this point. In addition, there cannot be tidal changes in the development of supercritical technologies, nor can it be felt that a failure to take up supercritical technologies would not be equivalent to revealing our own levels. Also, the level of subcritical technologies also could be revealed, so there is much room for debate.

V. Some Proposals

Development of supercritical generating units should employ a positive yet careful attitude, and it should study the Japanese experience.

The China Electrical Engineering Society made full use of the advantages of horizontal relationships, and they should continue to play their role on the basis of this conference. It would be best if special academic groups were established within the society, such as the establishment of a supercritical parameter thermal power generation research society within the Thermal Power Generation Society that would call scheduled scholarly conferences and assist the relevant departments in studying and formulating development plans for supercritical technologies.

A great deal of scientific research work concerning power generation with supercritical generating units must be done, and it is hoped that the State Science Commission will include scientific research work on supercriticality in state plans for attacks on key problems. It also is hoped that rational arrangements can be made for new technologies to increase thermal efficiency based on their own realistic qualities.

The discussions were especially concerned with the importance of metallic materials, and it was hoped that the Machinery Commission, the Ministry of Metallurgical Industry, and all of the relevant metallic materials research organs throughout China will cooperate in their efforts to provide high quality and inexpensive metallic materials for subcritical and supercritical generating units in China.

Higher demands are placed on valves, water supply pumps, high-pressure heaters, automatic control equipment and other equipment associated with supercritical generating units. Selection of the associated equipment should be done on the basis of overall generating unit safety, economy of operation and a consideration of manufacturing costs.

There was a difference of opinion during the conference concerning selection of reheated steam temperatures for the first supercritical generating unit. Some felt that choosing somewhat lower levels is mot appropriate and would permit success in the first battle. Others felt that low reheated steam temperatures would provide only small economic results, so they favor somewhat

higher levels. Regardless, however, everyone felt that availability rates and manufacturing costs were more important aspects. Improvements in economic results are possible only if availability rates meet requirements. Otherwise, higher efficiency would vanish into thin air. Failure to lower manufacturing costs would not encourage extension, especially given the serious lack of capital in China, which would make it very difficult for equipment with high manufacturing costs to solve the problem of power shortages.

Many comrades during the conference, both from manufacturing departments and from electric power departments, raised the question of employee quality as well as the problem of employee ethics. If these questions are not resolved, the goals of increased quality and lower manufacturing costs will be hard to achieve.

Supercritical generating units are a major step in the development of electric power equipment and involve very difficult technologies and much work. It is a step that is closely related to subcritical technologies imported in the past as well as future developments, so all relevant departments in China must centralize their forces for a common effort before it can be done well. I propose that a Thermal Power Equipment Promotion Group be established under the State Council Major Facilities Office with participation by the Machinery Commission, the Ministry of Water Resources and Electric Power, the Ministry of Metallurgy and the Ministry of Coal Industry to assume responsibility for formulating plans and coordinating work in all departments by playing a leadership role.

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RECOMMENDATIONS FOR APPLICATION OF SUPERCRITICAL PRESSURE GENERATING UNITS

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pp 4-8

[Article by Liu Chunsheng [2692 2797 3932] and Li Shouheng [2621 1343 1854] of the S&T Information Research Institute, Ministry of Water Resources and Electric Power: "The Developmental Situation for Supercritical Pressure Generating Units in Foreign Countries and Opinions Concerning the Development of Supercritical Pressure Generating Units in China"]

[Excerpts] According to the concepts of thermodynamics, higher steam parameters may raise cycle thermal efficiency, so all of the industrially developed nations increased their parameters from the 1950's to the 1970's and developed large capacity. Steam pressures developed from medium pressure through high pressure to subcritical and on to supercritical pressures. Some countries (like Japan) also have done research experiments in recent years on supercritical pressure generating units. Steam parameters, however, have a direct influence on the design, manufacture, and operation of the primary and auxiliary equipment, and they are directly related to the economy and safety of generator operation. As a result, decisions must be made on the basis of fuel prices, equipment manufacturing costs and manufacturing (including metallurgical) and operational levels. On the basis of a rather comprehensive understanding of the developmental situation in foreign countries and an analysis of the real conditions in China, the authors will offer some opinions concerning the development of supercritical pressure generating units in China for reference purposes.

II. The Current Situation of Thermal Power in China

Major improvements have been made in recent years in China in the areas of steam parameters and equipment capacity. Since the first Chinese-made 125 MW super-high pressure reheated generator went on line at the Wujing Thermal Power Plant in 1969, some 67 generators of the 125 MW class, 37 of the 200 MW class and 11 of the 300 MW class (including two natural cycle boilers) had gone into operation as of the end of 1986. Moreover, some generating units and manufacturing technologies were imported, and total installed coal-fired generating capacity reached 66,277 MW at the end of 1986.

Although substantial progress has been made in the electric power industry in China, it still is unable to satisfy the demands of industrial and

agricultural production. According to estimates for the most recent 3-year period, there was a shortage of 15,000 MW in installed generating capacity in China as well as a 60 billion kWh shortage of power output. Electricity shortages have become an important restrictive factor for development of the national economy. There are major shortcomings in Chinese-made generating units compared with foreign-made units in safety, economy and operational management. According to statistical data for 1986, the effective availability factor (EAF) of the 37 Chinese-made 200 MW generators was 73.859 percent, while the EAF of the 11 imported generating units was 77.44 percent. The figures for the Nos. 3 and 4 generators at the Douhe Power Plant (Japanese-made 250 MW generating units) were 98 percent and 86 percent, respectively. The average amount of coal consumed to produce electricity in China in 1986 was 432 g/kWh, which is 80 to 100 kg/kWh higher than in the Soviet Union and Japan. The main reason was that coal consumption for the 12,000 MW in low and medium pressure generating units reached 550 g/kWh, but coal consumption in the other types of generators also was too high. Coal consumption in Chinese-made 200 MW generating units was somewhat lower at 383 g/kWh. Coal consumption in the Soviet-made 200 MW generator at the Qinghe Power Plant, however, was 330 g/kWh. The figure was 368 g/kWh for the 300 MW Chinese-made generators at the Jianbi Power Plant and 320 g/kWh in the Japanese Mitsubishi 350 MW generating units at the Baogang Power Plant. Moreover, there are major discrepancies in the areas of automation levels and labor productivity.

III. Some Ideas Concerning the Development of Supercritical Generating Units in China

According to plans, total installed coal-fired generating capacity must increase from the 1986 level of 66,277 MW to 180,000 MW by the year 2000. This will require the installation of stable and reliable large capacity generators before the installed generating capacity can become effective (installing a unit and having it play the role of a unit) and reverse the passive situation of a power shortage. In consideration of the prices of fuel, iron and steel as well as manufacturing and operational levels in China at present, it would be more realistic to adopt large capacity subcritical pressure generating units and natural cycle boilers before 2000. This would involve adopting 200 MW and 300 MW generators in the short term and 300 MW and 600 MW generating units afterwards, with the 600 MW generators serving as the primary units by 2000, so that all of the generators placed into operation during the 1990's will attain the levels of similar foreign generating units. Although the thermal efficiency of subcritical pressure generating units is slightly lower than supercritical units, the higher availability rate of the generators also may provide real economic benefits.

The idea behind development of electric power from 2000 to 2015 is to double installed generating capacity, but it will be very hard for growth in energy resource output to keep pace with electric power. As a result, generator efficiency must be improved to conserve energy, and thermal generators must increase from subcritical parameters to supercritical parameters, which should be an effective measure for lowering coal consumption for thermal power. The developmental calendar for the future shows that both increased

generator parameters and greater capacity must go through the stages of preliminary discussion, policy making, development, elimination of "childhood diseases," normal operation and production in large amounts, which generally would require a decade or more to make it possible to adopt supercritical parameter large capacity thermal generating units after 2000. Technical preparation work should get underway immediately during the Seventh 5-Year Plan. First, a few technically mature supercritical generating units can be imported for study, testing and readjustment to explore their design and manufacturing characteristics as well as their operational performance. We also should study the developmental paths, current situations and problems that appear with supercritical generating units in foreign countries and borrow from them. At the same time, cooperation among hydroelectric, machinery and metallurgical departments should be organized for joint development of materials and large cast objects that are resistant to high pressures and high temperatures as well as to corrosion, as well as processing technologies and other things.

It can be seen from an examination of the developmental process and current situation of supercritical generating units in foreign countries that the ability to obtain economic benefits is determined by the concrete conditions and developmental paths of each nation. The current situation in China is one of serious power shortages, and the situation with thermal power equipment is one of low fuel prices and high iron and steel prices, while manufacturing levels and operational levels still are much inferior to those of the industrially developed nations. As a result, prior to 2000, we should improve and perfect the 300 MW and 600 MW subcritical generating units to bring them up to the levels of similar generators in foreign countries, and the adoption of natural cycle boilers would be most appropriate. At the same time, preparations should be made for electric power development after 2000. We should begin immediately to carry out technical preparation work for the development of supercritical pressure thermal power generating units including discussions of feasibility, research on importing mature generating units, the scientific research work required for development and so on.

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DISCUSSION ON DEVELOPMENT OF SUPERCRITICAL PRESSURE UNITS

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[Article by Chen Shangwen [7115 1424 2429] of the Science and Technology Office, Ministry of Water Resources and Electric Power]

[Text] I. Experience Abroad

More than 30 years have passed since the world's first supercritical generating unit for power generation was created and almost 500 of the units now are in operation worldwide. A comprehensive examination of the process in each country for development of supercritical generating units indicates that the overall trend is toward forward development, especially in the Soviet Union and Japan, whose determination is even more unshakeable. They have a great deal of experience and Japan especially deserves our study. The main aspects are:

1. Proper early choices must be made for generator parameters

The parameters of these units in the United States were too high during their early stages (a steam pressure of more than 300 kgf/cm^2 and a primary turbine steam temperature of more than 600°C) and the setbacks created many bad effects. The parameters of early Soviet and Japanese generators were more appropriate (less than 250 kgf/cm^2 and about 540°C), so their first battle was successful. Victory in an early battle concerns many questions and affects the overall situation.

2. Importing mature foreign technologies is a shortcut

Japan developed its units by importing technologies and prototypes from the United States and they went into operation smoothly. The Soviet Union depended entirely on its own technologies and design for manufacture. It had more problems when placing them into operation, required a longer period for maturation, and the quality was somewhat poorer.

3. Integration with national conditions to import and absorb the advantages of each country is essential for new development

On the basis of absorbing technologies from the United States, Japan worked to meet the need for additional conservation of domestic resources, and it

also demanded that thermal generators be used for load regulation because of the development of nuclear power stations. When it was discovered that European Bunsen-type monotube boilers were suited to varying-voltage operation for load regulation and that efficiency under low loads also was rather good, this technology was imported from Europe. The original vertical pipe exhaust manufacturing tradition was abandoned and a shift was made to manufacturing spiral-type pipes. Japan made many of its own innovations in the areas of steel, generator design and manufacturing technologies. The United States, however, stuck more to convention and did not learn quickly from the European advantages, so almost none of the supercritical generating units in the United States can be used for load regulation. According to statistics, the thermodynamic startup time for supercritical generating units in the United States is more than four hours in 97 percent of the cases and over seven hours in 36 percent of the cases. This is one of the reasons for the disappointment of electric power companies in the United States.

4. Solid scientific research work is essential if we are to pursue development independently

From the 1930's to the 1950's, Germany, the United States and the Soviet Union established supercritical pressure monotube boiler experiment stations, and Japan established one somewhat later in 1960. They obtained scientific information and a theoretical foundation for the development of supercritical generating units in each of the countries. During the 1950's, Japan began to develop steels for use in power generation equipment, and it started to study steels for use in supercritical generating units in 1960 and developed many new types of products. Japan's Electric Power Development Company (EPDC) now is developing scientific research work on even higher parameter 1,000 MW generating units. The most important of them is the Wakamatsu plan, which involves the conversion of a 75 MW gas turbine generator by Mitsubishi Heavy Industries into a 50 MW high-temperature experimental generator, and the completion of testing of components capable of withstanding 593 to 649°C is expected within 5 years.

5. Truly close attention to conservation of primary energy resources is the motive force pushing the development of supercritical generating units

The reason for Japan's active development of supercritical generating units is that Japan has a shortage of energy resources and must import large amounts of fuel at high cost. Moreover, the Japanese economy has developed very quickly in the past 20 years or more and electricity use has surged, making the need to conserve the fuel used for power generation an increasingly urgent demand. This is the motive force behind Japan's development of high-capacity supercritical generating units. Although the Soviet Union has abundant fuel resources, they are extremely concerned with conservation, so they have advocated the development of supercritical generating units. Of course, when the United States began to develop supercritical generating units, the reason also was to reduce fuel consumption, but many problems were found with the equipment in the early stages and major setbacks later did not change the situation. This is undoubtedly related to the relative abundance of fuel resources in the United States and to forecasts for the fuels used to generate power.

Although these points are of major concern, they are not the decisive factor behind a push to develop supercritical generating units. The deciding factors are the following three things:

1. Wise policymaking

To develop supercritical generating units, the Industrial Structure Survey Society of the Commercial and Industrial Provinces in Japan established a "Supercritical Pressure Thermal Power Generation Research Society" in 1961 under the responsibility of the Central Electric Power Research Institute and the Kansai and Tokyo electric power companies, and set up three auxiliary offices below them with a 58-member committee of renowned Japanese scholars and experts. The committees undertook wide-ranging survey research work and scholarly activities and carried out feasibility research. They issued a research report in 1962 which confirmed the feasibility of developing supercritical generating units in Japan. In 1964, the Resource Survey Society of the Japan Science and Technology Office proposed some opinions concerning development of supercritical generating units and confirmed this developmental orientation.

2. A feeling of crisis

The Japanese felt a sense of crisis and believed that if they did not make an all-out effort to surpass other countries scientifically, technologically, and economically, they would be unable to exist and could not take their position in the world. This spirit led them to hold to their goals in all activities and struggle heroically to make progress until they ultimately were successful.

3. Fierce competition

Enterprises in capitalist countries are fiercely competitive, and the electric power equipment manufacturing enterprises in Japan were even more so. Japan's thermal power generators are at the stage of generational change from subcritical to supercritical, and the rising capacity grades and speed of development are unprecedented. In contrast, China seems to have difficulty in walking, so our need to study the experiences of Japan well is even more urgent.

II. Integrate with China's Situation To See the Necessity of Developing Supercritical Generating Units

1. Coal conservation and shipping volumes

China's electric power industry will continue to be dominated by coal-fired power for a rather long time to come. Although China has abundant coal resources, the need to meet the demands of a growing economy means that coal supplies will continue to be inadequate (it has been estimated that yearly output will have to reach 2.1 [sic] billion tons by the end of this century before demand can be satisfied). The electric power industry is the largest user of coal, so extreme attention should be given to conservation. The current average efficiency of China's thermal power plants is very low, only

28.6 percent. If this efficiency rate were increased 1 percent, 5 million tons of coal could be saved, which is a very considerable amount. This estimate was based on the situation in 1986.

Second, China's coal resources are unevenly distributed, with the primary producing areas being located in Shanxi, Nei Monggol and Shaanxi. Currently, the coal used in eastern and southern China must be shipped by land and water for distances of 2,000 to 3,000 kilometers from Shanxi Province. Moreover, there are great shortages in shipping capacity that will not decrease in the future. Conservation of the coal consumed for electric power would make a major contribution to reducing the amount of coal shipped.

2. The use of supercritical generating units to generate power is the most realistic route for greater thermal efficiency in power generation

Other forms of power generation in pursuit of greater thermal efficiency for coal fuel include integrated coal gasification steam combustion cycles, magnetohydrodynamic generation, fuel cells and other forms, but all of these forms are in the experimental stage and have not been placed formally into commercial operation. Almost 500 supercritical generating units have gone into formal operation worldwide and although the parameters of most are in the preliminary stage, the parameters of quite a few units are rather high and the accumulated experience is quite abundant. Manufacturing companies in Japan, the United States, Germany and other nations are very confident about development of supercritical generating units. Japan's first-stage supercritical generating units were realized very quickly, so many in the United States feel that the United States' past failure to pay attention to development of super-supercritical generating units while being overly concerned with integrated coal gasification cycles was a mistake.

3. They also are economically justifiable

4. Modernization of power generation equipment requires the development of supercritical generating units

One aspect of China's modernization goals is that China's technological levels must reach international levels of the 1970's and 1980's by the end of this century. Existing supercritical generating units in other countries must be considered to be at the technical levels of the 1970's and 1980's. Also, generator capacities in China cannot remain forever at the 600 MW grade, so continued development will make adoption of supercritical parameters even more rational and necessary.

The four points above show that the feasibility of supercritical development in China should be re-examined.

III. Feasibility

If China has already gained a complete mastery of subcritical generator manufacturing technologies, then the transition to manufacturing supercritical generating units should not be difficult. Looking at the present situation,

however, the following problems exist concerning China's need to manufacture supercritical generating units:

1. The manufacturing technologies for the supercritical 300 MW and 600 MW generators already imported by China have not been digested well, the test generators still have not gone into operation, and the technical transformation work in plants to produce these generators in large amounts has not been completed.

2. Although the quality of Chinese-made generators has improved, they are not sufficiently stable, shortcomings exist in designs and materials quality, the quality of valves and water pumps is not good, no significant advances have been made in automated equipment, and users still are very uneasy.

3. Scientific research work concerning supercritical generating units still has not become the order of the day, and the former testing stations run by the Shanghai and Harbin Boiler Plants have been abandoned. The lack of activity in research work is especially true concerning materials, and technical preparations are lacking.

4. The self-supply rate of steel for power generation equipment is low and the rejection rate of large cast components is high; coal is of poor and variable quality.

5. The quality of operating personnel is not high.

Given this sort of situation at present, many comrades still have doubts regarding the development of supercritical generating units in China at the present time, especially those who are familiar with Chinese-made equipment and those comrades who have experienced great suffering because of equipment accidents. They feel that forces should be concentrated now to do good work involving subcritical and super-high pressure generating units, and that there is no need at present to take up supercriticality, which is something that should wait until later (some say 30 years). Such opinions are, of course, somewhat justified. Manufacturing industries at present definitely should focus on subcritical and super-high pressure generating units to improve quality, increase the overall safety and economy of the complete generating units, strengthen services and treat work to develop supercritical generating units not as something that they should begin immediately to manufacture themselves but instead should be placed on their calendar.

1. The five problems outlined above are not just problems that must be solved to create the conditions for supercritical generating unit production but also should be problems that must be solved in current generator production. We cannot accept them as natural and should adopt policies and measures to deal with them quickly.

2. A long-term plan is needed for the development of power generating equipment in China. The development of supercritical generating units is the direction and primary content of future development of power generating equipment in that the formulation of plans for development of supercritical

generating units is virtually the same as the formulation of development plans for China's power generation equipment.

3. Our neighbor to the east, Japan, has developed supercritical generating units at a rapid pace. The situation is pressing, and we must adopt countermeasures if we do not wish to lag behind.

IV. Proposals Concerning the Development of Supercritical Generating Units

There have been major activities in China's development of large thermal power generators in the past decade and more. The first instance was organization to develop 600 MW generators, and the other instance was importation of manufacturing technologies for 300 MW and 600 MW generators. Both of these activities, however, were for the purpose of manufacturing single-purpose generating units and were not done for long-term planning for the development of power generation equipment, leading to phenomena like persistent contradictions, too many things to take care of and so on. Such a plan should make comprehensive arrangements for the whole situation and be linked to practical work through long-term plans and arrangements. The time has come to formulate a long-term development plan for power generating equipment that includes work to develop the first supercritical unit to take an independent developmental path for modernization of power generating equipment.

To achieve this purpose, I propose that a Power Generating Equipment Promotion Planning Commission be established within the State Council's Large Technical Equipment Office, with participation by experts from the Ministry of Machine Industry, Ministry of Water Resources and Electric Power, Ministry of Metallurgical Industry, Ministry of Coal Industry and other ministries and commissions and institutions of higher education. There should be a small number of carefully chosen people, and three sub-committees should be set up below them under the lead of the Shanghai Institute of Power Generating Equipment Outfitting and Design, the Harbin Institute of Power Generating Equipment Outfitting and Design, the Xi'an Institute of Thermodynamics and the Liangxiang Institute of Electric Power Construction, with participation by experts from all fields. The top commission should make unified arrangements for all those concerned in assigning development work, and the work content should be the following nine areas:

1. Survey research

First, systematic processing of the data that can be gathered in China concerning the developmental situation for supercritical generating units in foreign countries should be carried out to discover the advantages and shortcomings of each country's equipment as well as the strong and weak points in their work and use comparative analysis to gain a deeper understanding. At the same time, surveys also should be carried out concerning the manufacturing situation for Chinse-made power generating equipment as well as research concerning the need to create the conditions for manufacturing supercritical generating units.

Afterwards, goal-based examinations of foreign countries can be done, with a focus on Japan and Europe to clarify certain questions like:

(1) What was the preparation work, manufacturing capacity and other conditions of these nations when they began development of supercritical generating units.

(2) Why did supercritical generating units develop so quickly in Japan, and what were their actual experiences.

(3) What was the basis for the decision to divide the development of supercritical generating unit parameters in Japan into three stages in the beginning and in the future, and what was the actual situation with the trial manufacture of the first supercritical generating unit.

(4) The best operational conditions with lowest coal consumption for supercritical generating units, the technical indices and amount of maintenance work required for each type, the characteristics of the primary and auxiliary equipment and automated equipment, and equipment prices.

(5) The various types of experimental work required to design and improve supercritical generating units.

(6) The situation in the development of steel for supercritical generating units.

(7) Ways to guarantee the quality of large cast components.

(8) Coal purification work.

The questions to understand regarding foreign countries, of course, cannot be limited to the above issues and can be decided upon during later stages of work. China now is preparing to import foreign supercritical generating units and trade negotiations provide a very good opportunity to understand the related situation in foreign countries, so we cannot relax.

2. Formulating development plans

Development plans include:

(1) A situation appraisal, including manufacturing capacity and levels for China's power generating equipment, current problems, studies of what is required to attain the capacity to manufacture supercritical generating units, what measures of encouragement should be adopted and when it can be attained.

(2) Work to develop the first supercritical generating unit: determination of parameters and capacity; selection of primary and auxiliary equipment, and an examination into whether or not the best primary and auxiliary equipment and automated equipment available in the world at present for the turbines, generators and boilers can be chosen to form the most reliable and highest capacity new generating units; whether or not we should import prototypes or technologies and the estimated costs; the conceptual design and

technical indices of the first generator as well as the estimated manufacturing costs; research and proposals concerning manufacturing units and an installation site for the first generator.

(3) Plans for the transition from manufacturing the first supercritical generating unit to large-scale production of supercritical units as well as the problems that must be solved.

(4) Decisions concerning whether or not we should follow Japan's example in plans for additional future increases in generator parameters and capacity.

(5) The scientific research and experiment work required for development of supercritical generating units and future development.

(6) Proposals concerning ways to manufacture the steel used in power generating equipment and how to base it on China's own resources, as well as concerning large cast components and ways to improve the quality of coal.

(7) Technical transformation projects required for the relevant manufacturing plants.

(8) Besides the project investments involved for these items, estimates of the costs also are needed.

3. Develop scholarly activities

Scholarly meetings can be called as work progresses to hold academic discussions, and scholarly groups can lead or independently undertake discussions of the relevant questions to foster academic democracy and wide-ranging collection of ideas. Strive to participate in international scholarly activities.

4. Propose suggestions to the state

After the above work has been done the sub-committees may submit their own research reports, and a "Plan for Promotion of Power Generation Equipment Manufacturing in China" may be submitted to the state following comprehensive study by the commission.

After this plan is approved by the state, the commission should take responsibility for supervising the implementation of the plan and for revising the plan every 2 years.

The above involves software compilation work for major countermeasures, and work should be done well in all items of present work at each of the manufacturing plants to gain sufficient confidence from users concerning equipment quality and to accelerate the pace of progress in enterprise reform and technical transformation in an effort to create the conditions for manufacturing supercritical generating units. It is hoped that each of the manufacturing plants, especially [turbogenerators], boiler, water pump, valve, advanced processing and automated equipment manufacturing plants, each will do their work in this area well and strive to complete the glorious tasks of manufacturing the first Chinese-made supercritical generating unit.

12539/7358

STUDY ON DEVELOPMENT OF SUPERCRITICAL PRESSURE UNITS

40130006d Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 8, 5 Aug 87 pp 12-15

[Article by Chen Binmo [7115 6333 1075] of the Machine Industry Commission Electric Power Bureau: "An Inquiry Into the Development of Supercritical Pressure Generating Units in China"]

[Text] I. The Necessity of Adopting Large Capacity Supercritical Pressure Generating Units in China

By the 1950's and the beginning of the 1960's, the advanced industrial nations of the world already had developed and grasped experience in manufacturing and operating supercritical and super-supercritical pressure thermal generating units, and West Germany, the United States, the Soviet Union, and Japan ranked first in the world.

The technical levels of China's thermal power generating equipment are far below those of the advanced industrial nations of the world, and we have never manufactured a single supercritical pressure generating unit, so we must push ahead.

Economic construction in China now is flying forward. If the economy is to develop, then electric power must lead the way. Based on the demands of the macroeconomic goal of quadrupling the national economy by the end of this century, power output must surpass 1,200 billion kWh and the installed generating capacity must reach 240 to 260 million kW. This includes 900 billion kWh from thermal power and an installed thermal power generating capacity of 180 million kW. China's electric power industry is dominated by coal-fired plants and although we have rather abundant coal resources, supplies will continue to be inadequate to meet the needs of continual economic growth. For this reason, besides the need for active development of nuclear energy and other energy resources, the developmental orientation of thermal power generating equipment not only requires very rapid increases in kWh but also requires that methods be found for major conservation of primary energy resources. In addition, the reliability and load flexibility of generators must be improved, and the generators developed in the future must not only have high thermal economy at full loads but also must have excellent performance at partial loads and under startup and shutdown conditions.

China's coal producing areas are concentrated in Shanxi, Nei Monggol and Shaanxi, while the power use load is in the eastern coastal region, eastern China and southern China, all of which must receive power transmitted from Shanxi at a distance of 2,000 to 3,000 kilometers. The need to overcome the difficulties involved in shipping coal over long distances means that energy conservation and decreased coal consumption are urgent tasks. The average amount of coal consumed to provide power in China's 6 MW and larger generators has reached 431 g/kWh, which is about 100 g/kWh higher than advanced world levels. In 1985, for example, an additional 30 million-plus tons of coal was consumed to produce the additional thermal power, which is a very considerable amount. For this reason, improvements in generator thermal efficiency in China cannot be delayed. The need to develop supercritical pressure generating units is the primary measure for improving generator thermal efficiency.

II. Opinions on the Development of Supercritical Pressure Generating Units in China

1. Develop Chinese supercritical pressure generating units on the basis of improved manufacturing and operational levels for subcritical and supercritical parameter thermal generators.

After China manufactured its first 6 MW thermal generator in 1955, it then went on to manufacture and put into operation 12 MW and 25 MW medium-pressure generators and 50 MW and 100 MW high-pressure units. The first Chinese-made 125 MW and 200 MW super-high pressure reheated generators went into operation in 1969 and 1972, respectively, and the first Chinese-made 300 MW subcritical generator went into operation in 1975 at the Wangting Power Plant in Jiangsu Province. Major advances have been made in the steam parameters and installed generating capacity of China's thermal generating units, and there were 64 super-high pressure reheated generators of the 125 MW class, 46 of the 200 MW class and 11 of the 300 MW class by the end of 1985. To improve the economic and technical standards of thermal power generating units and raise their efficiency to permit further satisfaction of the needs of China's electric power industry, manufacturing technologies for 300 MW and 600 MW subcritical pressure generating units were imported from the United States' Westinghouse Company and Fuel Engineering Company. The 300 MW generator now is being installed and adjusted at the Shiheng Power Plant in Shandong Province and is expected to go into operation by June 1987. The 600 MW generator now is being installed at the Pingyu Power Plant in Anhui Province and its adjustment and operationalization is predicted for June 1988. The 300 MW subcritical generating units that were designed and manufactured by the Shanghai Single Unit Power Generating Equipment Plant have undergone several years of perfection and improvement and 11 of them have gone into operation. The 300 MW subcritical generating units developed by the Dongfang Single Unit Power Generating Equipment Plant (with 1-meter-long final stage vanes) now is being installed at the Huangtai Power Plant in Shandong Province, and its operationalization is expected in the Fall of 1987. Although major advances have been made in thermal generator manufacturing in China, we still cannot meet the needs of agricultural and industrial production, and the primary contradiction at the moment is the power shortage. A major effort should be expended prior to 2000 to improve the manufacturing, design, construction

and operational levels of 300 MW and 600 MW subcritical pressure generating units as well as the 200 MW super-high pressure generators, and on this basis we should undertake development of supercritical pressure generating units. Smooth development of supercritical pressure generating units will be possible only by dealing well with improvements in the technical level of the primary equipment used in subcritical pressure generating units, the corresponding auxiliary equipment, high-pressure valves, automated control equipment, etc., and solid work on materials resistant to high temperatures. The 200 MW super-high pressure generators have undergone several years of improvements production in small lots, but accidents have occurred during operation, so they still cannot be considered mature generating units. They are quite inferior to advanced foreign levels in relative availability rates and efficiency, and major improvements remain to be made in manufacturing, design, installation and operational management levels. According to statistics for 1986, the equivalent availability coefficient of the 37 Chinese-made 200 MW thermal generators was 73.85 percent, while the equivalent availability coefficient of 98 and 86 percent, respectively, for the Japanese-made 250 kW No. 3 and No. 4 generators at the Douhe Power Plant, and 90 percent, 80 percent and 87 percent, respectively, at the 200 MW Soviet-made No. 5, No. 6, and No. 7 generators at the Qinghe Power Plant. The Harbin Steam Turbine Plant has improved the structural design of its three-cylinder three-exhaust 200 MW steam turbine and changed to a three-cylinder dual-exhaust structure with a final stage that employes 710mm long vanes. It now has been placed into operation successfully at the (Gudu) Power Plant in Pakistan. On this basis, the Harbin and Dongfang Steam Turbine Plants worked together to develop a three-cylinder dual-exhaust 200 MW steam turbine with 800mm long final stage vanes and the plan is for it to begin operating in 1988. The Beijing Heavy Electrical Equipment Plant also is preparing to use the 850mm long final stage vanes which have been tested in operation for four years in an improved three-cylinder dual-exhaust 200 MW steam turbine. The Chinese-designed 300 MW subcritical pressure generating units also require further perfection through operation. The imported 300 MW and 600 MW subcritical pressure generating units require serious work to digest and absorb them, and the associated components, materials, large cast parts, forged components and other things should be based on Chinese sources to lower the manufacturing costs of the generators.

For this reason, the 300 MW and 600 MW subcritical generating units will continue to be the primary generators prior to 2000. We should combine a good focus on super-high pressure and subcritical pressure generating units with taking the first steps to assure that supercritical pressure generating units gradually come to account for a definite proportion in China's power grids in the future. The steps should be taken quickly but carefully. We must draw on collective wisdom and absorb all useful ideas and make comprehensive planning arrangements. We can import technologies or produce them cooperatively. We should base our efforts on China's own resources, and we must organize to reinforce scientific research and basic work. The State Planning Commission has made a preliminary decision to import complete sets of supercritical generating units during the Seventh 5-Year Plan. They include two 600 MW supercritical generating units and a Soviet-made approximately 500 MW supercritical generator for the Shidongkou No. 2 Power Plant. This requires

that purchases of complete sets of equipment should be combined with importing the technologies related to supercriticality which we still have been unable to master, and there should be some cooperative production. This can gradually increase the proportion of supercritical generating units installed in China's power grids during the Eighth 5-Year Plan and subsequent 5-year plans, and it is a positive measure. Under leadership by higher levels, we should make use of the initiative of all areas and organize to transform the situation of the inability of China's electric power industry to adapt to development of the national economy.

2. Good choices should be made concerning generator capacity and steam parameters

To reduce consumption of primary energy resources and increase the thermal efficiency of generating units, we should continue to focus on research and development concerning the topics of increasing single unit capacity, increasing steam parameters and optimized thermodynamic systems. Increased single unit generator capacities can reduce consumption of primary energy resources and also has many advantages in decreasing unit investments per unit kWh, but there are definite limits to increased single unit capacity. When the capacity reaches a certain extent, the results of simply relying on increased single unit capacity to reduce fuel consumption are insignificant. Moreover, increased single unit capacity means that equipment dimensions must be increased and investments will be larger. The steam turbines, for example, would need more exhaust outlets and an increased exhaust area. The axle systems also would be too long, which could cause thermal expansion and blockages and other negative phenomena. Most of the supercritical generating units in operation in foreign countries have capacities in the 600 MW to 800 MW range. The single unit capacity is 676 MW in the United States and 586 MW in Japan. The Soviet Union already has produced fifteen 500 MW generators and twelve 800 MW units. China has decided to install two 600 MW supercritical pressure generating units at the Shidongkou No. 2 Power Plant. China now is involved with trial manufacture of the imported subcritical pressure generators, so it would be most suitable if the single unit capacity of the first supercritical pressure generating unit should be 600 MW. This would provide two types of steam intake parameters for 600 MW subcritical and supercritical pressure generating units which could be used for structural design, technologies, materials, automated control and other things. In addition, this could serve the needs for electric power development in different regions. For example, regions where the price of coal is lower could install subcritical pressure generating units, while regions where the price of coal is high could install supercritical pressure units.

Improvements in steam parameters mainly involve proper selection of preliminary steam pressures, preliminary temperatures and reheating temperatures. Higher steam parameters lead to corresponding increases in generator manufacturing costs and power station investments costs, and they require improvements in supplies of materials tolerant to high temperatures and large cast components, and higher levels of design and manufacturing for auxiliary equipment, high-pressure valves, automated control equipment and so on. Comprehensive analysis should be done concerning all of these questions to facilitate the determination of rational parameters.

Higher new steam pressures can increase cycle thermal efficiency, but they also demand increased water supply pump power consumption. General calculations are that if the preliminary steam temperature and the reheating temperature are set at 535°C, and if a single intermediate reheating is chosen, the heat consumed in a 600 MW generator can be reduced by about 1.6 percent when the preliminary pressure is increased from 165 kgf/cm^2 to 240 kgf/cm^2 in a situation of unchanged preliminary temperature and reheating temperature. If the preliminary temperature is increased continually, the increased power consumption of the pumps would not be clearly economical, so if the preliminary steam temperature and the reheating temperature are set at 535°C, it would be best to select a new preliminary steam pressure of 240 kgf/cm^2. Most preliminary pressure parameters employed in the United States, the Soviet Union and Japan at present are 245 kgf/cm^2, and 538°C/538°C or 538°C/566°C usually are chosen for the steam preliminary temperature and reheating temperature. China's thermal power generators, both super-high pressure and subcritical pressure, should choose these levels for preliminary temperatures and reheating temperatures, mainly by adopting austenite steel. After comprehensive analysis and comparison at the Shidongkou No. 2 Power Plant, the choices were a preliminary steam pressure of 245 kgf/cm^2 (surface pressure), a preliminary steam temperature of 538°C and a reheating temperature of 566°C.

On the basis of the above analysis and in consideration of actual levels in China's electric power industry, I propose that China's first-generation supercritical generating units adopt a new steam pressure of 245 kgf/cm^2, a preliminary temperature of 538°C and a reheating temperature of 538°C or 566°C.

3. The selection of the shape of supercritical pressure generating units in China

The selection of the shape of supercritical pressure turbines and boilers in China should be done in consideration of long-term development and also through integration with current design, manufacturing and operational levels in China. Regarding the turbines themselves, if preliminary steam temperatures and reheating temperatures are not raised but remain instead at the 535°C/535°C level, the base pressure of the turbines could remain basically the same when the steam pressure is increased from subcritical parameters to supercritical parameters. Low pressure cylinders for the 600 MW steam turbines that now exist in China can be used, while the structural design of high and medium pressure cylinders must be changed. After increasing the working pressure of the high-pressure cylinders, the thickness of the cylinder walls must be increased substantially, which makes it easy for the steam cylinder walls to undergo heat deformation and affects their reliability. It also would have negative effects on generator startup and shutdown performance and load flexibility. When steam pressures are increased from subcritical parameters to supercritical parameters, the base pressure component of the turbine can remain basically the same. China's existing low pressure cylinders used in 600 MW turbines can be adopted, but some of the structural designs for the high and medium pressure cylinders will have to be changed. After working pressures of the high pressure cylinders are increased, the cylinder walls must be much thicker since they are prone to thermal deformation of the cylinders and can affect reliability. In addition, they also

would have negative effects on generator startup and shutdown performance and on load flexibility. In most cases, multi-layer cylinder structures are adopted which reduce wall thickness and lower the pressure differential between the interior and exterior of the cylinders. Switzerland's BBC Company has adopted inlaid sleeve-type inner cylinders with two semi-circular non-level median surface flanges, while West Germany's Siemens Company uses entirely circular sleeve-type non-level median surfaces installed axially. These two structures have positive benefits in lowering thermal stress on the cylinders and thermal deformation, but they are different from China's traditional structures. The technology is difficult, as is processing. They also are hard to install and remove and very difficult to repair. Another type of structure uses narrow and thick level median surface flanges, and special flange heating equipment can be used. The shape of the cylinders should be simple and the dimensions of the upper and lower halves can be symmetrical and nearly spherical. Every effort should be made to reduce the diameter to permit thinner cylinder walls. In addition, the BBC Company turbines have a reactive structure, with the static blades installed directly on the cylinders and the regulator stages welded directly on the rotor. The technology is very difficult and hard to master. Because of the greater pressure differentials in a pulse-type structure, the partitions must be thicker and the axial dimensions of the cylinders and rotors must be increased. This structure is complex and has its advantages and disadvantages. Given that China has more than 30 years of experience in designing and manufacturing turbines and has taken a tortuous path, much experience has been explored and this certainly should serve as a foundation for making use of already imported manufacturing technologies and good selection of turbine shapes. It would be best to absorb the advantages of already digested reactive and pulse patterns and use a steam seal girdle inside the thick static blades and inner and outer cylinders with narrow and thick median surface flanges.

The boilers. The Shanghai Boiler Plant began designing and manufacturing 220 ton/hour spiral tube monotube boilers in the 1960's, and later they designed and manufactured similar style 400 ton/hour monotube boilers as well as 1,000 ton/hour vertical tube monotube boilers. Through continual perfection, their operational conditions are excellent. To develop supercritical pressure generating units for varying-voltage operation in integration with real conditions in China, it would be most appropriate to adopt a Bunsen-type spiral tube monotube boiler.

4. Operational patterns for supercritical pressure generating units

Supercritical pressure generating units have higher thermal efficiencies. The actual choice between adopting fixed voltage operation or varying-voltage operation should be determined by their role in electric power systems. For many years, supercritical pressure generating units have been used mainly to bear basic load operation, where the best economic results are found. Because of the rapid development of nuclear power station technologies, the industrially developed nations have adopted nuclear power generators on a broad scale because of their large capacity and economy to bear basic load operation. This requires that thermal power stations operate under conditions of intermediate loads, cyclical loads, peak loads and other variable load working conditions to meet the need for peak regulation, rapid startup and

shutdown, low nighttime loads, weekend shutdowns and other types of load regulation and improve power grid economy. This demands a certain degree of operational flexibility in supercritical pressure generating units as well as the ability to adapt to load changes quickly. To assure that its supercritical pressure generating units can meet the need for varying-voltage operation, Japan imported spiral rising water cooling wall tube technologies from West Germany. In recent years the Soviet Union also has focused attention on research concerning the adoption of varying-voltage operation patterns for its supercritical pressure generating units, and its 300 MW subcritical pressure generators can be placed into varying-voltage operation at 77 percent of rated load. Its 800 MW supercritical pressure generating units can make the transition to varying-voltage operation conditions at 89 percent of rated load. China's Shidongkou No. 2 Power Plant uses a repeated varying-voltage operation pattern in which the generators can adopt fixed voltage operation at $\leq$25 percent loads, varying-voltage operation during 25 percent to about 85 to 90 percent loads, and fixed voltage operation again from 85 or 90 percent to full loads. At this time, the boiler steam intake pressure and the boiler outlet pressure both change as the power load changes, which is achieved through boiler, boiler and generator control systems. Because the regulating valves of the turbine are in a fully open state, there are no throttle losses. The internal efficiency of the turbines under partial loads basically can be held at design working conditions. The adoption of varying-voltage operation in supercritical pressure generating units has its own special advantages in turbine structure compared with the usual nozzle regulation pattern. In addition, the drop in boiler outlet steam pressures under partial loads means that a corresponding reduction can be made in water supply pressures. This reduces power consumption in the water supply pumps and improves thermal economy under partial laods. The working pressures on boilers, pipelines, turbines and related components are lowered during times of partial load, which can extend the useful life of these components.

Based on the above analysis, the most appropriate operational pattern for China's first generation of supercritical pressure generating units would be based on the repeated varying-voltage operation pattern employed at the Shidongkou No. 2 Power Plant.

Comrade Chen Shangwen [7115 1424 2429] in the Ministry of Water Resources and Electric Power recently offered a very good suggestion to encourage faster development of supercritical pressure generating units in China and motivate initiative in all areas. By establishing an Electric Power Equipment Promotion Planning Commission in the State Council's Major Technical Equipment Office to organize and coordinate the related ministries and commissions for unified planning and unified coordination, step-by-step implementation and close integration to gain a grasp as quickly as possible on certain key materials, key auxiliary equipment and major scientific research topics, I am confident that supercritical pressure generating units will develop very quickly in China.

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DEVELOPING SUPERCRITICAL UNITS SAID BEST WAY TO MEET POWER EQUIPMENT DEMANDS

40130006e Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 8, 5 Aug 87 pp 15-20

[Article by Yang Lizhou [2876 4539 3166] of the Shanghai Boiler Plant: "The Best Way To Satisfy China's Power Generating Equipment Needs Is To Develop Supercritical Pressure Generating Units"]

[Text] I. Analysis of the Feasibility of Developing Supercritical Thermal Powered Generators in China

Although the equipment manufactured in each country have similar parameters and capacity, differences in designing, manufacturing and operational levels may create substantial variations in overall equipment efficiency. Or, there may be a distinction between subcritical and supercritical parameters while overall efficiency remains the same due to differences in design or other areas. The primary factor affecting efficiency, however, is steam parameters. It will be rather hard to increase generator efficiency to a significant extent if generator parameters are not increased to supercriticality or "hypercriticality." A failure to acknowledge this fact may lead to mistaken comparisons of unclear data on efficiency.

Before 1986, there were differences of opinion concerning whether or not supercritical generating units should be imported after 300 MW to 600 MW subcritical generators were imported. The opinions opposed to the supercritical generating units were: (1) The reliability of supercritical generating units is not as good as that of steam-jacketed boilers, while the most important power plant index is reliability; (2) Although the heat consumption of supercritical generating units theoretically is better than that of subcritical generators, the actual measured heat consumption of the two is nearly identical; (3) The operational levels of supercritical generating units must be higher and automatic control, valves and water processing are more difficult. As a result, it would not be economical for China to develop supercritical generating units, and moreover technical levels cannot meet the requirements. Technical personnel and leaders who hold this opinion can be found in both the Ministry of Water Resources and Electric Power and the Machine Industry Commission, so Shanghai made the decision in 1985 to use subcritical parameters and rejected supercritical parameters for manufacturing 600 MW generating units, and preparatory work has been carried out. This article will attempt

to analyze the reliability of developing supercritical 600 MW generating units in China, and it proposes that the 600 MW generating units at the Shidongkou No. 2 Power Plant in Shanghai adopt supercritical parameters and that integration of technology and trade be employed to solicit bids for importation.

1. The question of the reliability of supercritical generating units

The reliability of a thermal power plant has an enormous effect on its economy. Because the reliability of the early supercritical generating units in the United States was poor, their order rate as a proportion of the total volume of orders dropped from more than 50 percent in the 1960's to less than 10 percent in the 1970's, which had very negative effects on the development of supercritical generating units in the United States and throughout the world.

The United States' Edison Electric Research Society carried out detailed special surveys and statistics concerning the reliability of large capacity thermal power equipment in power plants between 1967 and 1976, and derived the following conclusions:

(1) The reliability analysis and some of the conclusions drawn about thermal power generators during the early period were superficial. No distinction was made between new products and old products for the generators included in the statistics, no distinction was made about whether micro normal pressure stove chambers were used or whether or not excessive capacity and sectional thermal loads were used, whether or not good quality bituminous coal or poor coal prone to clinkering was burned, nor whether or not the reason for the high accident rate was related directly to the supercritical parameters. Because the accidents with the generators were improperly classified, the results were somewhat superficial. The overall conclusion at the time was that the accident rate of supercritical generating units was about 5 percent higher than for subcritical generators, and that increased generator capacity led to higher accident rates. The equipment experiencing the greatest accident rate was boilers (see Table 1).

Table 1. Comparison of Accident Rates (in Percent) of Coal-Burning Thermal Power Generating Equipment

Power	300~600MW		800MW	
Parameters	Sub-critical	Super-critical	Sub-critical	Super-critical
Boilers	6.7	10.5	7.6	11.5
Steam turbines	1.9	3.3	2.9	4.0
Condensers	0.1	0.1	0.1	0.2
Auxiliary equipment	0.8	0.6	2.8	2.8
Other	4.6	4.6	6.6	6.6
Total	14.1	19.3	20.1	25.1

(2) Table 2 and Figure 1 show the results of differential statistical classification and analysis for the availability rates of the 54 coal-fired generators ranging from 600 to 825 MW in power.

Table 2. Availability Rates of Coal-Burning Generators

Type	Parameters (kgf/cm², °C)	Number of units	Average capacity (MW)	Average years of use	Average Availability rate (%)
1	169,538/538	19	635	5.6	72.9
2	246,538/538	25	704	5.2	71.6
3	246,538/552/566	10	715	7.5	77.5

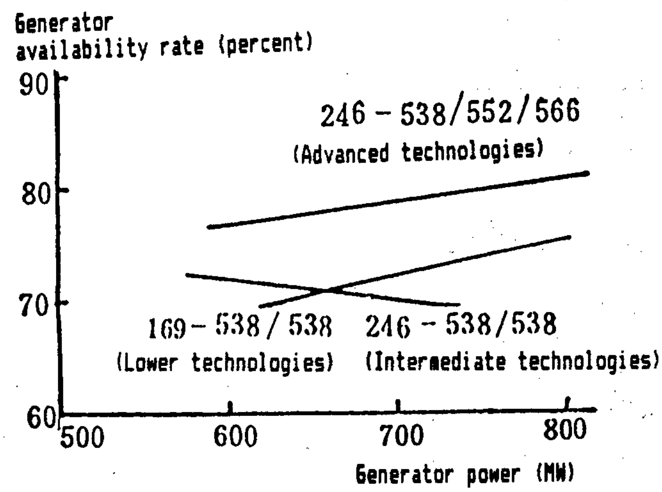


Figure 1. Availability Rate Trends of Coal-Burning Generators

It is apparent that the availability rates for large capacity dual-reheating supercritical generating units are higher than subcritical generators of less capacity and single reheating supercritical generating units. The availability rate curves for the supercritical generating units rise as capacity increases, but the curves of the subcritical generating units decline as capacity increases.

(3) A distribution chart analyzes the availability rates of the 55 coal-burning supercritical generating units and 20 subcritical generating units (both having a capacity equal to or greater than 600 MW) (see Figure 2).

It is apparent that for the generators with higher than average availability rates, supercritical and subcritical units are about the same. The top 10 percent availability rates are supercritical generating units, which are better than the optimum steam-enclosed boiler generators, while the bottom 10 percent also are supercritical generating units.

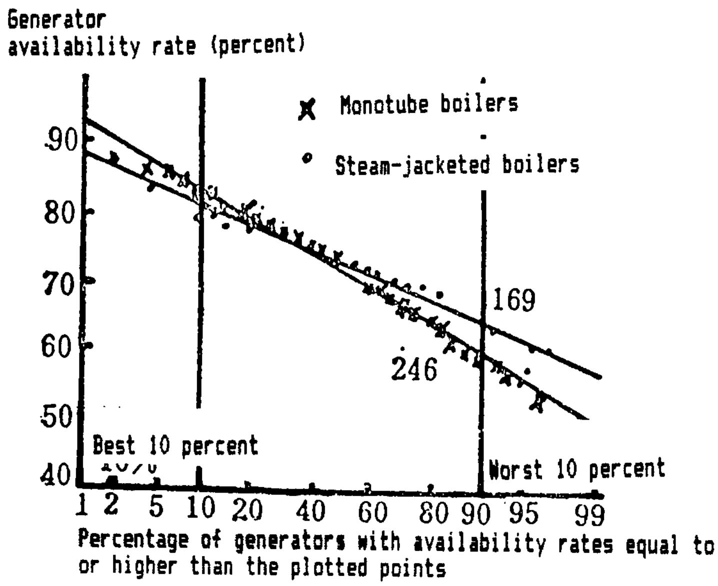


Figure 2. Distribution of Availability Rates

The results of the above three stages of analysis show that the availability rates of supercritical generating units definitely are not lower than those of subcritical generating units. The availability rates of Japanese supercritical generating units generally exceed 90 percent, and their accident rate is less than 1 percent. Some of them can even attain availability rates as high as 100 percent.

Before 1986, certain people in China based their opposition to the development of supercritical generating units on the poor availability rates of the United States' supercritical generating units during the early stages.

2. The heat consumption question in supercritical generating units

In the area of raising steam parameters and lowering heat consumption in the generators, there are differences among the various companies arising from differences in statistical design, component structures and so on. The following trend data can be derived by properly arranging these data. They were calculated using the criteria of 169 kgf/cm^2 and 538/538°C.

When steam pressure is 169 to 316 kgf/cm^2 and steam temperature is 535° to 600°C, each 10 kg/cm^2 rise in steam pressure can decrease heat consumption in a power plant by 0.18 to 0.29 [percent]. The amount of reduction decreases as the steam pressure rises and rises with increases in steam temperature.

When the steam pressure is 169 to 316 kgf/cm^2 and the temperature is 535° to 600°C, each 10°C increase in steam temperature can decrease power plant heat consumption by 0.24 to 0.36 percent. The amount of reduction decreases as the steam pressure rises and rises with increase in steam temperature.

When steam heating is increased from one reheating to two reheatings, power plant heat consumption can decline by 1.7 to 2.4 percent. This amount increases as steam pressure rises and declines as steam temperature rises.

For example, the heat consumption in a dual-reheating 246 kgf/cm^2, 538/552/566°C supercritical generating unit is about 5 percent less than a power plant with 169 kgf/cm^2, 538/538°C subcritical generating units. This is a very large differential efficiency value.

3. Analysis of technical feasibility

(1) When compared with two 300 MW generators of like parameters, a 600 MW generator in foreign thermal power generating equipment can reduce investments by 15 to 20 percent, while maintenance costs are 40 percent lower, 20 percent less land is taken up, heat consumption can decline by 0.5 percent, and manufacturing and installation schedules are correspondingly shorter. During the rapid industrial development of the various nations of the world, every one of them has resorted to increased generator capacity to solve problems during periods of urgent demand for electricity. The increase in generator capacities, however, is restricted by the capacity of power grids. If we examine China's 12 existing power grids with installed generating capacities over 1,000 MW, we find that four of them with capacities in excess of 10,000 MW can adopt 600 MW or even larger generators. Many more power grids will be able to handle large capacity generating units by the 1990's. China has had chronic power shortages for the past decade, and the main causes were inadequate investments and insufficient supplies of Chinese-made large capacity generating units to meet demand. As a result, China's adoption of 600 MW generating units as a substitute for 300 MW generators is an important measure for conserving on equipment investments, increasing output and conserving coal.

Most of the advanced foreign nations adopted supercritical parameters for their thermal power generating units when their capacity reached 600 MW.

(2) When the steam temperature of large capacity thermal power generating equipment remains at 538°C while the steam pressure rises from 169 kgf/cm^2 to the supercritical 246 kgf/cm^2, heat consumption can be improved by 1.5 to 2 percent while the cost per unit kWh rises by only about 1 percent. If the steam pressure is not changed and the primary steam temperature is increased from 538°C to 566°C, heat consumption rises by only about 0.75 percent, while the cost per unit kWh usually doubles in comparison with the former case. It is obvious that an increase in steam pressure from subcriticality to supercriticality without increasing steam temperature is especially conducive to reduced investments. Increased steam pressures cause rather small changes in product types and materials, while an increase in temperatures requires the adoption of more austenite stainless steel and

increases the investments, and it also creates technical problems like welding unusual types of steel, high temperature corrosion and so on.

(3) Peak-to-valley differentials in China's power grids at present remain at 30 to 50 percent. Although the thermal power generating equipment now being produced has a suitable variable load capacity, the economy of low-load operation and flexibility at variable loads are not the best. When China develops 600 MW supercritical generating units, attention should be given to the ability of the generators to bear basic loads and to whether or not these generators will be able to operate in adaptation to sliding voltages, to bear intermediate loads and to have excellent low-load operational economy and flexibility at various loads. A Bunsen-type boiler with a water cooled walled tube spiral return path in the stove chamber can adapt to both of these demands. Moreover, tube diameters are larger and they do not require throttle rings or internally threaded pipes, nor does it produce film-state boiling or pseudo-film state boiling. When burning poor quality coal, the boilers still retain a definite degree of safety and reliability. The manufacture of a single-spiral return circuit water cooled walled pipe is more complex than vertial film-type pipes. When a front and back wall counter-pulse swirl-type burner is used, not a great deal of time is needed to manufacture them. When a quadrangular combustion oscillator-type burner is used, the degree of complexity increases and the amount of time needed for design and manufacture is greater. In consideration of the lower manufacturing costs, the adoption of swirl-type burners would be more suitable for spiral return circuit stove chambers. Besides the need to import supercritical technologies, this also makes it even more important that new combustion technologies be imported, which makes their common use in plants complex. Having both types of combustion technologies, however, also meets China's needs.

(4) The Shanghai region began designing and manufacturing its own 50 MW spiral return circuit water-cooled wall monotube boilers in the 1960's, and later it also produced more than ten 300 MW subcritical monotube boilers, both of which laid the foundation for trial manufacture of varying-voltage operation supercritical 600 MW generating units. Given China's production conditions and the lack of thick steel plate and heavy equipment, manufacturing supercritical monotube boilers would be more complicated than manufacturing subcritical steam enclosed boilers. Designing a varying-voltage operation supercritical boiler also would be harder, so we should adopt an integrated technology-trade pattern and import the technology to speed up development.

The blueprints for the imported subcritical 600 MW gas turbines can be borrowed for the medium and low pressure steam cylinders used in supercritical 600 MW turbines. We must only make new designs for the supercritical pressure steam cylinders or instead import the blueprints and materials. Other things like valves, automatic control equipment, water processing equipment, superheating bypasses and so on are components specific to supercritical generating units, so we must import the equipment and technologies and get training in foreign countries in operation, maintenance, management and other areas for the first generator.

To permit better digestion and development of the experiences of foreign countries, integrated technology-trade importing and copying should be combined with our own experimental research and continual development, including the development of new types of steel, for additional development of technical levels to create a firm foundation for increasing the availability rates of China's supercritical generating units. Only in dealing with these questions conscientiously can supercritical generator technologies be mastered.

4. Analysis of economic feasibility

China is a complete blank when it comes to supercritical generating units, so when doing economic analysis it is necessary to adopt the principle of combining technical and economic data from foreign countries with actual conditions in China. Table 3 was formulated in this manner. The table uses program 1 for subcritical generating units as a basis for comparison with supercritical generating units. In the table, the heat consumption values and increased investments in programs 1, 4, and 5 were derived from data from the United States, while programs 2 and 3 were calculated from the afore-described experiential data on heat consumption and interpolation. The investment for 600 MW subcritical generating units was 810 yuan per kW, which is equivalent to the 952 yuan per kW for 300 MW generators (assuming that the difference between the investments is 17.5 percent), which is close to the current price in China. The actual utilization time of 7,000 hours in China was used for the generator operating time and the price of coal was assumed to be 70 and 100 yuan per ton for the two types of standard coal. Because the operating and maintenance expenses of supercritical power plants are lower than for subcritical power plants, they were not calculated. According to the calculations, the number of years required to recover the additional investments would be 1.8 to 2.9 years calculated using the lower coal price and 1.1 to 1.8 years using the higher price for coal. The total amount of coal conserved by each generator during its 30-year lifetime would be 720,000 to 3.62 million tons of standard coal. It is apparent that there would be substantial economic benefits if China were to develop supercritical generating units, and one also can see that given the chosen coal price levels, program 4 is the best generating unit in its suitability to China's conditions, and that program 2 is second best.

The adoption of varying-voltage operation for supercritical generating units is quite economical during low load varying-voltage operation and can conserve 10 to 25 percent more coal than generators which operate at fixed voltages (this was not included in the calculations) depending on the length of time operated at low loads, but there would be a corresponding reduction in the number of kWh generated during a year's operating period.

Table 3. Comparative Economic Analysis of 600 MW Generators with Different Steam Parameters

Item / Program	1 169kg/cm² 538/538°C	2 246kg/cm² 538/538°C	3 246kg/cm² 538/566°C	4 246kg/cm² 538/550/566°C	5 317/kg/cm² 538/550/566°C
Total investment for power plant (yuan/kW)	810	816	822	825	843
Increase in investments (yuan/kW)	0	6	12	15	33
Net heat consumption in power plant (kcal/kWh)	2478	2438	2418	2357	2277
Annual coal savings (tons of standard coal/kW)	0	0.04	0.06	0.121	0.201
Annual savings in Renminbi (yuan/kW)	0	2.8 ~4.4	4.2~6.6	8.5 ~13.3	14.1~22.1
Recovery period for increased investments (years)	0	2.1~1.4	2.9~1.8	1.8 ~ 1.1	2.3 ~ 1.5
Percentage increase in investments	0	0.7	1.5	1.9	4.1
Percentage decrease in heat consumption	0	1.6	2.4	4.9	8.1
Amount of coal conserved during life of generator (10,000 tons of standard coal)	0	72	108	218	362

A comparative method was employed for the above analysis of economic feasibility, and the calculations are simple and reliable. Given the complete lack of supercritical generating units in China, certain people have found it very easy when analyzing the economic feasibility to calculate the total investments for a supercritical power plant too high while setting the price of coal in China too low. They use erroneous heat consumption values in the design, manufacturing and operation of the early supercritical generating units and make comparisons with the already mature subcritical generating units, so naturally it is easy to derive the conclusion that the economic results from development of supercritical generating units in China would not be very great.

5. Macroeconomic feasibility analysis

When a socialist country selects new power generating equipment it must employ the thought and logic of modern systems engineering to study major questions related to overall national interests. This is a different standpoint and concept adopted by a socialist country when preparing to construct a power plant in comparison with a capitalist. Some of the more important issues are:

(1) Manufacturing 600 MW supercritical boilers can eliminate the heavy steam jacket made of 200 mm steel plate, large diameter dropping pipes, round collector boxes and other pipes and components. This means that the 300 ton grade large plant building and raw materials as well as the processing,

hoisting and shipping equipment required for processing these heavy components is unnecessary, and it can conserve on the fuel needed for high temperature forging pressures, thermal processing and welding processing as well as power and welding materials. Therefore, given China's production conditions, the technologies involved in manufacturing supercritical 600 MW boilers are simpler than subcritical boilers of similar capacity and have a shorter production period. Moreover, the raw materials basically can be supplied by domestic sources, and expanded production also is more convenient. It is apparent that the development of supercritical pressure generating units can accelerate the pace of thermal power equipment in China.

The Nagasaki Plant of Japan's Mitsubishi Co. can produce 8,000 MW of supercritical boilers each year. China's three largest boiler plants all have three automated production lines responsible for coal conservers, superheaters and film-type walls for manufacturing pressure-bearing pipes and components. The quality of welding is reliable and inspections are strict, so with only appropriate additional transformations and outfitting, [a plant] could produce 4,000 to 6,000 MW of supercritical boilers each year, meaning that the three plants together have a 12,000 to 18,000 MW production capacity. Other manufacturing plants with similar capacities have not been included in these figures, so they could provide the boilers needed to meet China's power shortages.

Boilers are the weak line in the inability of thermal power generating equipment supplies to satisfy demand. If the boiler output problem is solved, other things like turbines, generators, auxiliary equipment and so on will be easier to provide.

Some have calculated that the serious power shortages in China have reduced the GNP by 20 percent. If we assume that major efforts to develop supercritical generating units could increase the GNP by 10 percent before the year 2000 because of sufficient supplies of electricity, this would be equivalent to an increase of more than 250 billion yuan in increased gross value of social output. These macroeconomic benefits cannot be ignored.

(2) Supercritical generating units also can develop in the direction of hypercritical generating units, which is an important direction for future development of thermal power equipment. If they participate in heat and power co-generation systems or are linked into a cycle with gas turbines and magnetohydrodynamic power generating equipment, efficiency could be improved even further. The amount conserved for the state would be even greater.

It is apparent that early development to produce as many as 600 MW or even larger capacity supercritical generating units as is possible could provide China with power generating equipment in a faster, better and more economical manner and solve China's long-term and intractable power shortage problems, so it is of great significance.

II. Developmental Trends Before 2000 and the Steps and Measures To Be Adopted

Thermal power will account for more than 70 percent of total electricity generation in China in the year 2000. Nuclear power will account for only about 0.3 percent and hydropower will make up the remainder. The proportion of thermal power in Japan has declined gradually, but they still are striving to move forward in development of supercritical thermal power generating units. Since China is to be dependent on thermal power to raise production levels and living standards before and after 2000, faster and better utilization of the integrated technology-trade pattern to develop advanced supercritical generating units is technically feasible, economically beneficial and conforms to the characteristics of production in China, so it is the best route and inevitable trend to satisfy the demand for power in China.

China already has produced Chinese-made 300 MW subcritical pressure generators, and the manufacture and preparation for operationalization of the imported 300 to 600 MW generating units now is underway. Progress has been made in the heat consumption indices of China's thermal powered generators as well as in the technical levels of design, technology, inspection, automation control and so on.

This grade of generators will become the primary power generating equipment during China's Seventh 5-Year Plan. For this reason, we must strive to master the imported technologies and integrate with our own research and development to improve their performance, quality and automatic control as well as the levels of auxiliary equipment like valves, and we should carry out complete unit optimized designs and design according to different standards of coal varieties to prepare the conditions well for continued production of large numbers of reliable and advanced generating units before the end of this century.

The proposal that Shanghai develop 600 MW supercritical generating units has been agreed to by the State Planning Commission and an integrated technology-trade pattern will be used to solicit bids for the two 600 MW supercritical generating units for the Shidongkou No. 2 Power Plant. It has been estimated that the first generator will go into operation in 1990, and supercritical 600 MW generating units can be produced in large numbers within China beginning in the Eighth 5-Year Plan. To assure smooth development of supercritical generating units, preliminary consideration should be given to the following opinions.

1. Bidding negotiations for the first 600 MW supercritical generator concern not only the price but even more importantly are related to the ability of the supercritical generating units to generate power faster, better and more economically. This is closely related to the following technologies, and it is hoped that the relevant units will take them into consideration when deciding on the bids.

(1) It would be best if the steam temperature parameter adopted for the first supercritical generating unit were 540/540°C instead of 540/566°C.

(2) It would be best if better-quality bituminous coal that is not prone to clinkering were selected as the coal type actually used in the first supercritical generating unit to favor early victories and development.

(3) The type of boiler chosen should be a Bunsen-type stove chamber with water cooled wall pipes and spiral rise.

(4) To adapt to the manufacture of Bunsen-type boilers, swirl-type burners should be employed to facilitate the manufacture of water cooling walls and lower manufacturing costs.

(5) Complete generating units should be outfitted with reliable advanced automatic control equipment.

(6) Automatic control technologies and their components, key valves, water processing technologies and agents and so on should be imported gradually and they should be further improved on the basis of technologies already imported for subcritical generating units.

2. More personnel can be sent abroad for study and training, and two people can participate in key topics to facilitate diffusion and extension. The foreign language and professional levels of the participating personnel should be good and the requirements for team leaders should be even higher. The personnel described above should have knowledge and experience with several monotube boilers and the selection should be made seriously.

3. By reference, China could produce as much as 20,000 MW in 600 MW supercritical generating units during the Eighth 5-Year Plan and the output during the Ninth 5-Year Plan can be several times this amount.

To adapt to the major development of supercritical generating units, work in the following areas must be done well before and after 1990: (1) Continue to publish treatises on supercritical generating units and integrate the relevant units to avoid repetition; (2) The related academic societies should establish special supercriticality research committees; (3) During preparations for construction as well as the installation, trial readjustment and operationalization periods, the Shidongkou No. 2 Power Plant should serve as a center for training supercritical generator operating personnel; (4) Shanghai should establish a supercriticality research and development center.

4. I propose that China's manufacturing plants should make every effort to participate in manufacturing, installing and trial adjustment during assembly of the second 600 MW supercritical generator at the Shidongkou No. 2 Power Plant, with foreign technicians providing supervision and advisory services. The copies of the other 600 MW supercritical generating units should be installed at other power plants in east China. When more advanced dual reheating 600 MW supercritical generators are installed for the Nos. 3 and 4 generators at the Shidongkou Power Plant, the parameters should be 250 kgf/cm^2 and 540/540/540°C. They also can be imported according to integrated technology-trade patterns to assist China in obtaining the design,

manufacturing and operational technologies for dual reheating generators, and to lay the foundation for the development of even more advanced supercritical and hypercritical technologies.

5. The Outline Plan for Advanced Technology Research and Development formulated by the Science and Technology Leadership Group in the State Council proposes seven technical realms including energy technologies, which encompass coal-burning magnetohydrodynamic power generation technologies and advanced nuclear reactor technologies. This realm will come to have a major influence on future economic construction in China, so it should strive for breakthroughs to keep pace with world levels. Given that the gradual achievement of hypercritical electrical generating unit technologies is integrated better with production, is more realistic and more economical, it is proposed that advanced supercritical and hypercritical generating units should be included in the Outline Plan for Advanced Technology Research and Development to unify ideology and activities within China. Guarantees should be provided for the necessary experimentation and research expenditures.

Table 4 compares the various coal-fired power generating system programs.

Table 4. Comparison of Programs for Various Coal-Burning Power Generation Systems

Type of installation	Earliest year of commercial operation	Heat consumption at full load operation (kcal/kWh)	Manufacturing cost ($/kW)	Single unit capacity (MW)
Advanced supercritical generating units with second reheated steam temperatures of 566°C 597/593°C and exhaust gas desulphurization	1992	2122	1105	750
Pressurized fluidized bed combustion, integrated cycles	1995	2134	875	650
Coal gasification integrated cycles, using a (Deshigu) coal gas furnace	1991	2384	1030	1000
Integrated coal-burning magnetohydrodynamic power generation cycle	2003	2280	1360	1000
Constant pressure fluidized bed, hot air turbines, integrated cycles	1993	2256	1000	300

Even more important is the hope that central and local leaders will provide the needed organizational assistance for development and production of both supercritical and hypercritical generating units and that quality planning and supervision arrangements will be made to encourage and promote good realization of this major strategic goal and the necessary logistics work.

12539/7358

GOVERNMENT SAYS POWER SHORTAGE TO EASE IN 5 YEARS

40130012a Beijing RENMIN RIBAO in Chinese 26 Sep 87 p 2

[Article by Yu Youhai [0060 2589 3189] and Jiang Shijie [3068 0013 2638]: "Measures Outlined To Ease Power Shortages"]

[Text] The CPC Central Committee and the State Council attach a good deal of importance to reforms in the power industry, power production, and the development of the industry, and are committee to taking firm measures in the two directions of increasing generating capacity and regulating the growth of ordinary electricity-consuming industries in order to ease power shortages in most areas within 5 years. This was disclosed by Deputy Minister Huang Yicheng [7806 2015 6134] of the State Planning Commission in his report to the national planning conference and the national economic restructuring work conference today.

The reform of the power industry, power generation, and the development of the industry have achieved great successes in recent years. As far as reforms in the investment system are concerned, a break has been made with dependence on the state for funds and the monopoly on power supply. The rudiments of a multi-sector, multi-level, and multi-channel setup for electricity generation are now in place. Regarding management, the industry has initiated a bidding system, which has given reform a good start. Concerning increases in installed capacity and electric power production, 7 million kW in generating equipment was put into service in 1986, to be followed by possibly 8 million kW in equipment this year. The average annual gain in power production in 1986 and 1987 will be more than 9 percent, a fairly high level in the world. Nevertheless, there is still a serious power shortage, forcing many enterprises to "suspend operations for 3 days after working for 4 days" and preventing many projects from going into operation upon completion. As a result, the nation suffers a total of 200 billion yuan in lost industrial output each year, gravely undermining the effort to improve social economic performance and state revenues. Huang Yicheng disclosed that the nation would take four specific measures to eliminate power shortages as soon as possible:

First, reform the present management system in the power industry. Inter-provincial electric network bureaus and provincial electricity bureaus will be converted into electric network joint companies and provincial power

companies, respectively. These companies will practice independent accounting, enjoy managerial autonomy, and be responsible for their own profits and losses. The idea is to increase the responsibility of localities for power production and consumption and seriously mobilize the enthusiasm of all parties for power production.

Second, popularize the practice of three provinces and one municipality in East China. A specified amount of power development funds should be collected and put into a special fund to finance local capital projects in the power industry. Electricity users must pay for the use of electricity. Moreover, a portion of the national technology transformation funds should be set aside each year to support power development, beginning in 1988.

Third, specify a base figure for power consumption by provinces, municipalities, and autonomous regions and clearly delineate the responsibilities of the central government and local authorities in providing electricity. The general principle is that the central government should build power plants to satisfy the electricity requirements of newly constructed key enterprises that manufacture centrally allocated products, while local authorities should put up power plants to provide the additional electricity required by other enterprises, agriculture, and urban domestic consumption. About the division of labor in plant construction, by and large regional super-large thermal plants, large hydropower stations, nuclear power plants, and key inter-provincial and inter-district electric networks should be built under the direction of the central government. Alternatively, investors may be allowed to buy shares in a plant, in which case property rights, the electricity generated, and the profits made will be distributed in accordance with the investment ratio. Localities should take the lead in financing and putting up thermal plants, hydropower stations, and related transmission and transformer projects that serve local needs.

Fourth, sort out the capital projects now under way, using the electricity supply situation as the main criterion. To avoid haphazard and overlapping projects and improve investment returns and economic performance, we must ascertain the electricity consumption of provinces, municipalities, and autonomous regions. Once that is done, construction on all projects without a guaranteed electricity supply, whether they are owned by the whole people or collectives, capital projects or technology transformation projects, production projects or nonproduction projects, must be stopped or suspended, to be resumed when there is a guarantee of electricity supply. In the future, construction on new projects can begin only after electricity availability is really assured. When a project is completed, the electricity use contract must be signed and stamped by the director of the electricity bureau. The bureau director must be held responsible for plants with no guaranteed electricity supply upon completion.

12581/12851

SHANGHAI TURNING OUT HEAVY THERMAL, NUCLEAR POWER EQUIPMENT

40130012b Beijing RENMIN RIBAO [OVERSEAS EDITION] in Chinese 6 Oct 87 p 1

[Excerpt] Shanghai to date has developed a capacity to manufacture such heavy equipment as large thermal stations, sedans, and machinery for the metallurgical, chemical fertilizer, building, and coal mining industries. Of these, the 300,000-kW generating set and nuclear power equipment match comparable advanced equipment in the world in quality and performance. Shanghai also can manufacture 15 kinds of electrical machinery that can replace imports, or 30 percent of the first batch of electrical machinery products slated by the state for import substitution.

According to a report in JEIFANG RIBAO, reform and the policy of opening to the outside world have enabled Shanghai's electrical machinery industry to develop rapidly and become an important base in the nation for manufacturing entire sets of vital plants. Shanghai's machinery industry has successively imported 208 pieces of advanced technology from abroad. The assimilation of foreign technology has been accompanied by the intensification of internal scientific research. In recent years the power station industry has imported technology to build 300,000 kW generating sets from Westinghouse Electric Corp, Combustion Engineering, and other companies in the U.S. After 6 years of absorption and assimilation, the first 300,000-kW generating set built with imported technology (including nearly 3,000 pieces of electrical equipment) has been put into operation at the Shiheng electric power plant in Shandong this year. Even as it works to develop conventional power plant equipment, the Shanghai electrical machinery industry has been mounting a vigorous push for nuclear energy. Almost 10 years and 130 million yuan worth of investment later, the industry is now basically able to manufacture 300,000 to 600,000-kW nuclear-energy generating sets. With the exception of certain imported equipment, Qinshan nuclear energy project boasts 1,366 pieces of Shanghai-manufactured equipment in 136 sets.

Phase II of the Baoshan Iron and Steel Complex is China's largest construction project during the Seventh 5-Year Plan. And one of the key projects of Phase II is the "2030" cold rolling mill. Shanghai's electrical machinery industry has mobilized 69 mainstay enterprises led by Shanghai Heavy Machinery Plant in a joint production effort together with 48 enterprises in other provinces and municipalities, SMS Schloemann-Siemag AG of West Germany, and 7 companies from the U.S. and Japan. Together they have undertaken the research and development of all the equipment in the project, more than 780 pieces all told. The performance and quality of all equipment has met specified requirements.

12581/12851

HYDROPOWER DEVELOPMENT ON UPPER HUANG HE OUTLINED

40130005b Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 8 Oct 87 p 1

[Article: "Pushing Hydropower Station Construction on the Upper Huang He--Five Completed Power Stations Have Enormous Benefits for Development of Northwest China"]

The five cascade power stations which have been completed are: Longyangxia, Liujiaxia, Yanguoxia, Bapanxia and Qingtongxia. They have a total installed generating capacity of 3.244 million kW and generate 15.75 billion kWh each year, equal to 31.6 percent of developable hydropower resources on the Upper Huang He. The conditions for development of the Lijiaxia, Daxia and Xiaoguanyin hydropower stations have been prepared, and feasibility studies for the Laxiwa, Gongbaixia, Jishixia and Daliushu stations are underway. Preliminary preparations for the Siquoxia, Xiaxia and Wujinxia hydropower stations will get underway soon.

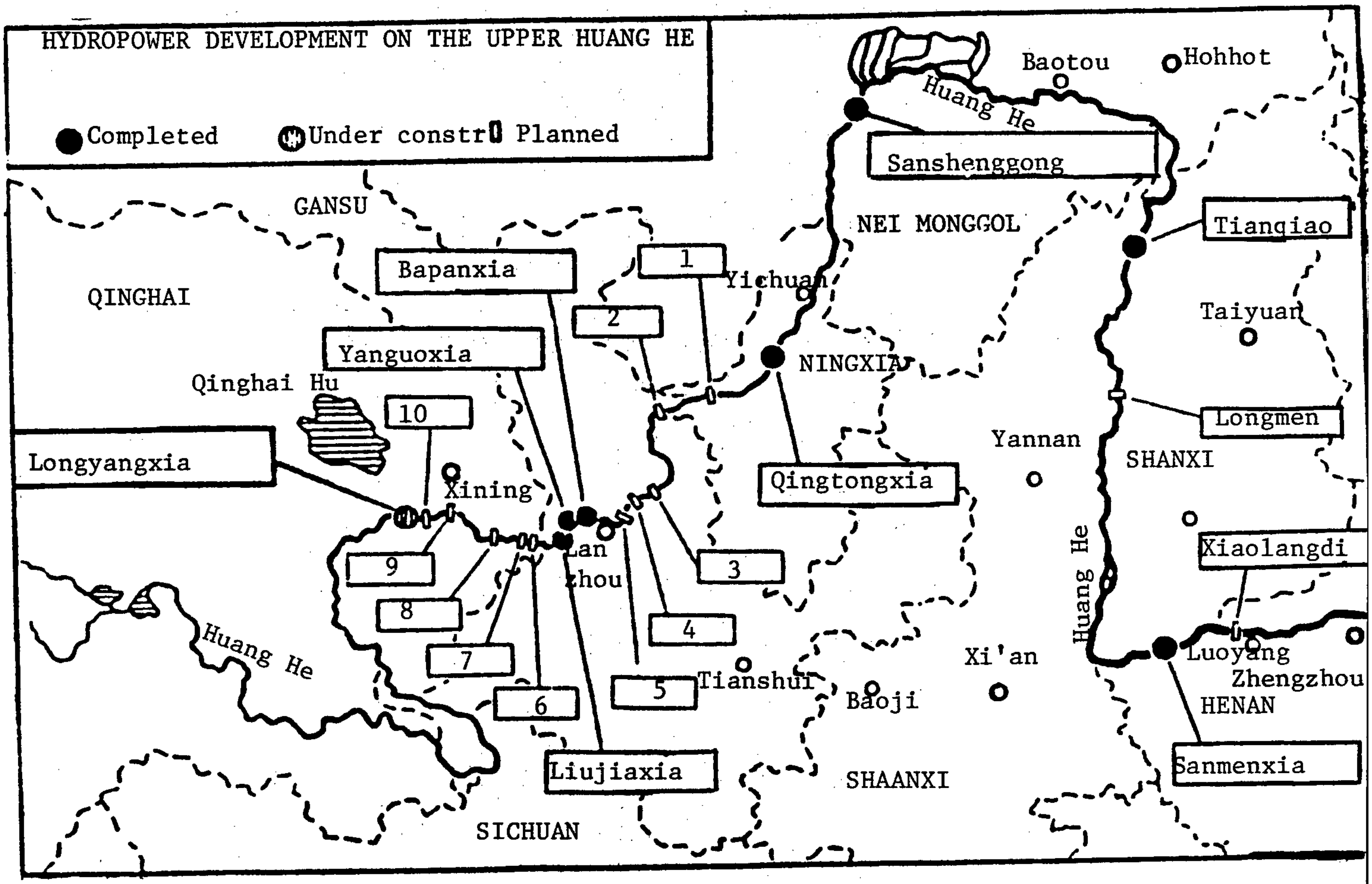
The Upper Huang He refers to the section of the river between Longyangxia in Qinghai Province and Qingtongxia in the Ningxia Hui Autonomous region, a distance of 918 kilometers. This section of the river has alternating gorges and mountains, and it has a torrential flow rate and concentrated drop. The natural water head is 1,324 meters and total usable head is 1,084 meters. The installed generating capacity may reach 13 million kW and generate more than 50 billion kWh each year. The region is China's "motherlode" of hydropower resources. Development of the hydropower resources of the Upper Huang He is of extremely great significance for controlling and utilizing the Huang He and development of northwest China.

China's plans for comprehensive development and utilization of the Huang He was proposed in 1954. After more than 30 years of unrelenting efforts, the hydropower employees achieved enormous successes. The five hydropower stations on the Upper Huang He are playing a major role and obvious changes are occurring in Qinghai, Gansu, Ningxia and other provinces and autonomous regions.

The five completed hydropower stations are the primary energy resource base area for industrial and agricultural production in Qinghai, Gansu, Ningxia and Shaanxi. They provide 15.75 billion kWh of power each year for non-ferrous metal smelting, petrochemical, iron alloy and other large energy consuming

industries and for high lift irrigation, which has promoted the development of industrial and agricultural production in the region. Qinghai, Gansu Ningxia, Nei Monggol and other arid provinces and autonomous regions have increased their irrigated area by 16 million mu and grain output has grown every year.

The big Longyangxia and Liujiaxia reservoirs can play an enormous role in regulation by effective collection and control of Upper Huang He water, and they have basically eliminated the danger of flooding and freezing on the Huang He and assured the safety of the lives and property of the people who live along it.



Key:

1. Daliushu	6. Sigouxia
2. Xiaoguanyin	7. Jishixia
3. Wujinxia	8. Gongbaixia
4. Daxia	9. Lijiaxia
5. Xiaoxia	10. Laxiwa

12539/12232

LONGYANGXIA'S NO. 1 GENERATOR NOW ON STREAM

40130005a Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 30 Sep 87 p 1

[Article: "First Generator at Longyangxia Hydropower Station Generates Electricity--Major Success in Controlling, Developing the Huang He--Entire Project To Be Completed in 1989"]

[Text] The world famous "spigot" project on the Upper Huang He--the main part of the Longyangxia Hydropower Station project--now has attained a preliminary scale. The first generator, with an installed generating capacity of 320,000 kW, was tested successfully and connected to the grid to generate power at 2310 hours on 29 September 1987. this is an effective indication of China's enormous successes in controlling and developing the Huang He.

The Longyangxia hydropower station is located on the Upper Huang He at the mouth of Longyang Gorge between Gonghe and Guinan Counties in Qinghai Province, and it is the first of 15 cascade power stations planned for development on the Upper Huang He. It plays an important role in controlling the water flowing in the Upper Huang He and in regulating the amount of water flowing downstream. It has become known as the "spigot project."

The 178-meter-high dam that had to be built for the Longyangxia hydropower station is the tallest dam built on the Chinese mainland. It required construction of a 24.7 billion cubic meter reservoir and installation of large Chinese-made 320,000 kW generators, both of which were the first for China's present hydropower stations.

Work on this project began in February 1976. More than 10,000 hydropower construction workers struggled for many years to complete the 174-meter-tall arched dam stands among the mountains and gorges, and the man-made lake now holds 6.1 billion cubic meters of water. The main power house, which can hold four large 320,000 kW generators,now is basically completed and the complex sluicing systems have taken shape.

A total of four generators will be installed here. Each unit will have a capacity of 320,000 kW, so the total installed generating capacity will be 1.28 million kW. Installation of the four generators will be finished by the end of 1988.

The Longyangxia hydropower station is a large-scale key project that will have a perennial regulation capability and provide comprehensive benefits. It is focused on power generation but also will play a role in flood prevention, irrigation, water supplies and prevention of ice. The information is that this hydropower station will generate 6.03 billion kWh of electricity each year and can also provide supplementary regulation of the Luijiaxia power station and increase power output in downstream cascade power stations by 640 million kWh each year. completion of the Longyangxia project will permit basic control of flooding in the Upper Huang He and will basically eliminate the danger of flooding and freezing. It will provide a net increase of more than 14.9 million mu in irrigated area and provide an additional 470 million cubic meters of water for urban and industrial use.

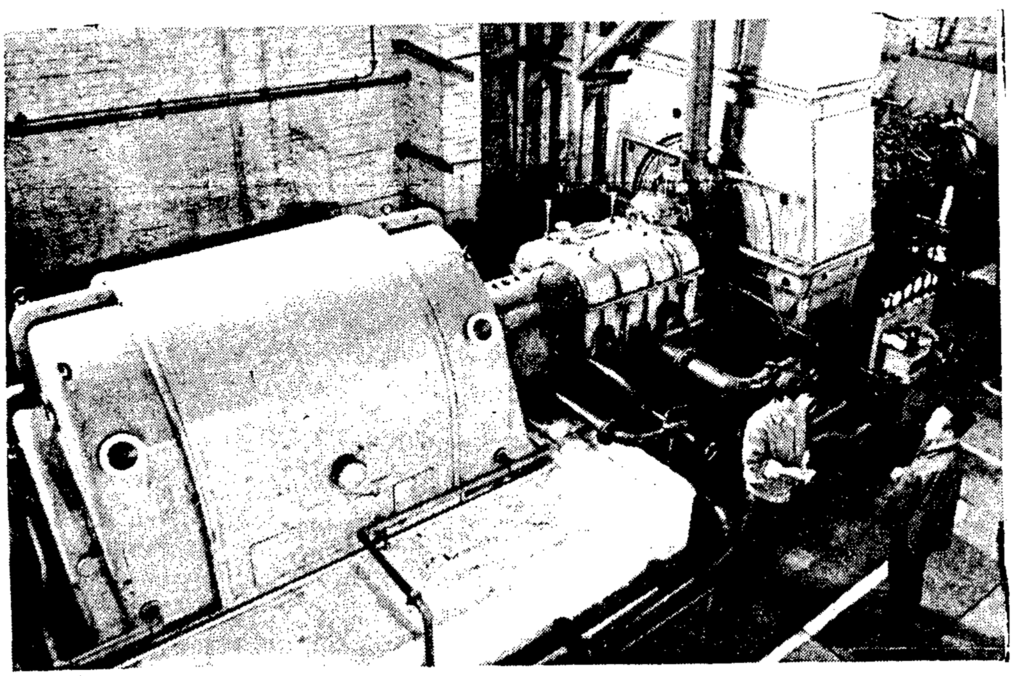
According to the information, the Longyangxia project will be finished completely in 1989.

12539/12232

GAS TURBINES MAY SEE WIDESPREAD INDUSTRIAL USE

Beijing KEJI RIBAO in Chinese 4 Sep 87 p 2

[Text] The Liming Power Machinery Manufacturing Company of the Ministry of Aviation Industry has developed China's first aircraft power plant to be used as an industrial gas turbine power generating plant; the turbine uses natural gas as a fuel. The plant is already in operation at the Daqing oil field. The gas turbine could see widespread application in both onshore and offshore oil production, construction in the border regions, and in improving energy conservation in industry and mining.



08309
CSO: 40130016

BRIEFS

CHANGSHAN PLANT EXPANSION--On 10 September the No 8 boiler of the fifth stage expansion project of the Changshan thermal power plant--a major construction item under the State's Seventh Five-Year Plan--was successfully lit off. The No 8 boiler is a major component of Jilin's first 200,000-kilowatt steam turbine generator set. Construction personnel overcame numerous problems to make the boiler operational in the space of 10 months and 10 days. [Summary] [Changchun JILIN RIBAO in Chinese 15 Sep 87 p 1] /8309

DOUHE IN FULL PRODUCTION--Recently, the Douhe power plant's 200MW No 8 generating set was installed and tested successfully, after which it officially joined the grid. The plant, under construction for 14 years, has a total installed capacity of 1.55 million kilowatts, the second largest in the country. The Douhe power plant, located in the northern part of Tangshan City, was constructed in four stages. In the first two construction stages four imported generators were installed but the four 200,000-kilowatt sets installed in the last two stages were completely of Chinese manufacture. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 16 Oct 87 p 1] /8309

JIANGYOU EXPANSION PROJECT--Work has begun on the expansion project of the main powerhouse of the Jiangyou power plant in Sichuan Province, a major project under the State's Seventh Five-Year Plan. According to plan, this expansion project should be completed in early April 1991, giving the Jiangyou power plant a total installed capacity of 884,000 kilowatts, and would make the facility the largest thermal power plant in Sichuan Province. [Text] [Beijing GUANGMING RIBAO in Chinese 2 Oct 87 p 1] 08309

CSO: 40130016

CONFERENCE MAPS STRATEGY FOR DEVELOPING ENORMOUS COAL BASE

Beijing RENMIN RIBAO in Chinese 23 Aug 87 p 1

[Text] Yinchuan, 22 Aug--China's "Energy Base Development Strategy Symposium" was convened on 19 August in Yinchuan City, the capital of the Ningxia Autonomous Region. This grew out of a State Council decision in 1982 to create an "energy base economic zone" to include Shanxi, Ningxia, western Nei Monggol, northern Shaanxi, and western Henan and marks the first such conference to be held by the State Council's Energy Base Planning Office.

This "energy base economic zone" made up of these five provinces (regions), is the largest energy base in China. On the basis of verified reserves, some 70 percent of the nation's coal resources would lie in this economic zone. Today, there are 24 provinces (cities, regions) that would utilize the coal from the economic zone. It is estimated that by the end of this century more than 90 percent of the nation's commodity coal will be supplied by this economic zone. As a result, studying the development strategy of the zone will be crucial to meeting the nation's energy requirements. Being constructed under the 6th and 7th 5-year plans, the economic zone's energy and high-energy-consuming raw materials industries that are based chiefly on coal already have a solid foundation. Railroads, which are the primary means of transporting the coal, have been improved [increased] greatly. Energy, transportation, and the heavy and chemical industries have assumed considerable scope and a number of key projects are now in the early stages of construction. The energy base, a major economic zone for the country, has already taken encouraging steps toward breaking down administrative barriers to promote the reform of the economic system and strengthen economic cooperation.

Some 200 officials, experts, and scholars attended the symposium representing the State Planning Commission, the State Science and Technology Commission, the Ministry of Coal Industry, the Ministry of Water Resources and Electric Power, the State Council's Shanghai Economic Zone Planning Office and the Beijing Economic Zone Planning Office, as well as the five provinces (regions) that make up the economic zone.

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CHINA NOW WORLD'S SIXTH LARGEST OIL PRODUCER

Beijing RENMIN RIBAO in Chinese 5 Sep 87 p 1

[Text] The Burea of Statistics of the European Economic Community (EEC) recently released figures showing that in 1986 the world's total crude oil production was some 2.914 billion tons, up 5.6 percent from the previous year's output of 2,757 billion tons.

In 1986, the Soviet Union led the world, with an output of 613 million tons, the United States was second with 280 million tons, Saudi Arabia was third with 247.6 million tons, the EEC was fourth with 143.7 million tons (of which 122.3 million tons came from Britain's North Sea fields), and Mexico was fifth with a production of 140 million tons. With an output of 129.6 million tons, China placed sixth among the world's leading oil-producing nations.

Middle East crude production grew sharply in 1986 to 666.2 million tons, up 25.8 percent from the 1985 output of 529.4 million tons. Australia and New Zealand saw the next largest jump with some 33.9 million tons being produced in 1986, up 21.9 percent from the 1986 production level of 27.8 million tons. OPEC production rose from 818.1 million tons to 950 million tons, an increase of 16.1 percent. Soviet production grew by 3 percent.

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SEVENTH 5-YEAR PLAN FOR PETROLEUM EQUIPMENT INDUSTRY OUTLINED

40130007 Lanzhou SHIYOU HUAGONG SHEBEI [PETROCHEMICAL EQUIPMENT] in Chinese, No 1, January 1987 pp 1-3

[Article by Chief Engineer Zhang Renqi [1728 0088 3825], Machinery and Electrical Equipment Bureau, State Planning Commission: "Goals for the Petroleum Equipment Manufacturing Industry in the Seventh 5-Year Plan"]

[Text] Petroleum equipment includes the two major categories of petroleum drilling and extraction equipment and oil refining equipment. Petroleum drilling and extraction equipment refers to the equipment used in exploration and development and includes specialized equipment, tools and components used for drilling, extraction, collection and transmission. Oil refining equipment refers to the technical equipment used in oil refining facilities like containers, towers, reactors and heat exchange equipment as well as various types of specialized equipment.

I. The Current Situation and Shortcomings

1. The situation of implementation during the Sixth 5-Year Plan

China's petroleum equipment manufacturing industry has grown substantially since the nation was founded. According to statistics for 1984, the industry had 80 specialized manufacturing plants, 10 research institutes, 158,000 employees (including 9,700 engineering and technical personnel) and fixed assets worth 2.25 billion yuan.

Production grew rather quickly during the Sixth 5-Year Plan (1980-1985). The gross value of industrial output rose from 1.314 billion yuan to 2.135 billion yuan, an average yearly growth rate of 10.2 percent, and the profits and taxes turned over to higher authorities reached 405 million yuan. Product output increased from 175,000 tons to 322,000 tons, an average yearly growth rate of 12.9 percent.

Improvements also have been made in quality standards. Following enterprise reorganization, comprehensive quality management, adherence to international standards, perfected measurement and testing methods and other basic work, the state had issued licenses to 27 pressure vessel manufacturing plants for designing and manufacturing three types of pressure vessels by the end of

1985, and the Lanzhou Petrochemical Industry Machinery Plant has received an ASME license from the United States. Some 150 new products were completed during the Sixth 5-Year Plan, including 4,500 meter drill rigs, toothed gear wheel drill bits and other things which have approximated advanced levels for similar products in foreign countries. There now are 328 types of petroleum equipment products at foreign levels of the late 1970's and 30 percent have reached early 1980's levels. China now is about 70 percent self-sufficient in petroleum equipment. Products awarded United States API Society awards include oil sampling shafts, oil sampling machines, slurry pumps, hanging rings and so on.

2. Problems that exist

(1) Technological and grade levels are low. Some 70 percent of petroleum drilling and extraction equipment is at 1950's and 1960's levels in foreign countries.

(2) Manufacturing capacities for large scale equipment are weak. As petroleum equipment develops toward high efficiency, energy conservation and larger scales, the demand for large equipment will increase, but China's present production capacity cannot satisfy demand.

(3) Completeness is poor and automation levels are low. Because product specifications for petroleum equipment are limited at present, complete sets of equipment cannot be provided to users. Automation levels are low for most testing, recording and control equipment and the needs of users cannot be satisfied.

(4) Enterprise quality is rather low. Educational levels and technical qualities of personnel staffs are low, equipment is old and technologies are backward. The ability to develop new products is poor, manufacturing periods are too long and testing measures are incomplete.

II. The Goals, Tasks and Focus of the Seventh 5-Year Plan

The goals of the petroleum equipment industry during the Seventh 5-Year Plan (1985-1990) are: By 1990, to build an independent design capacity and assure that product specifications basically meet oilfield and oil refining industry development needs. The performance and quality of more than 50 percent of primary products should attain the levels seen in the industrially developed nations during the late 1970's and early 1980's, and major breakthroughs should be made in completeness and automation levels.

According to petroleum industry plans, petroleum output in China will be 150 million tons and natural gas output will be 15 to 20 billion cubic meters in 1990. It is predicted that 240,000 tons of oilfield equipment must be produced in 1990, up 20 percent over 1985. Production of oil refining equipment must reach 92,000 tons.

During the Seventh 5-year Plan, 170 new products will be developed. International standards or advanced foreign standards will be used for all of the new products. There will be obvious improvements in the reliability and adaptability of the products.

Digest and absorb technologies imported during the Sixth 5-Year Plan and form the capacity for production in large amounts. During the Seventh 5-Year Plan, another 22 new technologies will be imported.

In 1990, the gross value of output in the petroleum equipment industry will reach 3.55 billion yuan, up 66.3 percent from 1985. The plan for foreign exchange earnings from exports is $10 million (the 5-year total is $25 million, up 62 percent from the Sixth 5-Year Plan). The amount of profits and taxes turned over to higher authorities will reach 640 million yuan, up 42.2 percent from 1985. The capital profits and tax will reach 28.7 percent, up 31.9 percent from 1985. Average yearly labor productivity for the entire industry labor force will reach 15,000 yuan per worker, up 36.4 percent from 1985.

To adapt to the need for exploration and development in deserts, along the coast and other regions and to utilization of high-pressure jet drilling, balanced pressure drilling, directional drilling, cluster drilling and other new technologies in the petroleum industry, the quality of petroleum drilling and extraction equipment and tools should be improved as a basis for observing the United States API standards and for systematic development of product types.

Manufacturing technologies for oil refining equipment should involve better understanding and improvement of large oil refining equipment. We must make every effort to increase production capacity and focus on development and production of hydrogen refining and hydrogen cracking equipment. Study the vacuum filterers needed for lubricating oil facilities, casing crystallizers and other new products. Strive to add new heat exchanger products and expand the number of product types in this area and cooperate to organize for specialized production. Digest already-imported plate-type heat exchanger manufacturing technologies and form the capacity for batch production quickly.

III. The Primary Measures

1. Reinforce organization and develop various forms of integration.
(1) Integrate manufacturing and applications departments for joint formulation of industrial development plans and technical equipment policies for petroleum equipment. Do good work in integration of technology and trade, combine imports of complete sets or single pieces of petroleum equipment with imports of design and manufacturing technologies, and deal with foreign countries in a unified manner. (2) Integrate military and civilian uses. Make full use of technical and equipment advantages in military industry departments, extract their strong points and supplement their weaknesses and make joint attacks on highly technical and difficult petroleum equipment. (3) Integration of enterprises. Based on the principle of specialized production and cooperation, rationally arrange production and organize enterprise groups formed by amain force of certain key enterprises and a foundation of medium and small enterprises. Integration is particularly important in the electronics industry, which should develop integrated electromechanical petroleum equipment and also use electronics technologies (especially computers) to transform the quality of machinery enterprises.

2. Reinforce industrial management and services. Strengthen work in the China Petroleum Equipment Society and assist government administration departments in active development of professional activities like offering evaluations and suggestions concerning technology imports and equipment import projects, circulating technical information and suggesting opinions on technical economics policies and legislation, strengthening macroeconomic control and so on.

3. Work conscientiously to place quality first and strengthen user services. Safety and reliability must be the primary concern, and enterprises should practice comprehensive internal quality management and reinforce supervision and inspection. External competitive bidding should be set up for the enterprises to form a buyer's market. In addition, enterprises should work actively and in a planned and gradual manner to adopt U.S. API standards. Enterprises also should shift from simple manufacturing to a "threesome" of manufacturing, repair and technical services and they should strengthen information feedback to facilitate improvements in product designs and technologies. Moreover, enterprises should undertake system and project responsibility for complete-set production and equipment supplies.

4. Actively expand exports. Development of petroleum equipment should look both to the Chinese and international markets and, under the prerequisite of meeting domestic needs, strive to export more products on international markets and participate in international competition to encourage improvements in China's product levels. Use a stable foundation of existing export product quality to expand the volume of exports; use the foundation of improved product adaptability to expand the variety of products; use close integration of industry and trade to reinforce sales and post-sales services as foundation for expanding markets (the so-called "three expansions"). Gradually establish industrial export production systems and make a gradual transition from bottom shelf products to top and middle shelf goods. Make a transition from mainly exporting single pieces of equipment to diversified export patterns like contractual responsibility for complete sets and project items (the so-called "two transitions").

5. Gather together the necessary talent and materials to improve scientific research and design levels and to reinforce technical development work. One thing is to strengthen construction of specialized research institutes and establish close integration with enterprises to become true professional technical development centers. Another thing is to push scientific research units toward vertical integration and horizontal integration as well as cooperation and joint development. Use a division of labor for cooperation on key topics in the development of the industry's production and technology. The third thing is to organize industry or supra-industry technology markets and mutual exchange, and for extracting advantages and making up for shortcomings, especially in the need to transplant military technologies for use in the development of petroleum equipment technologies.

6. Raise product standardization, systemization and generalization levels to facilitate the organization of specialized production. Supplies of blanks and

components should be organized well. Policies should be adopted for preferential economic treatment of the specialized plants which make blanks and parts to provide additional assistance.

7. Make focused technical transformations. Petroleum equipment manufacturing enterprises should carry out transformations in a planned and gradual manner guided industry plans to improve the quality and competitive abilities of enterprises. The focus of technical transformation should be reinforcement of scientific research development and testing conditions to transform and improve technical production technologies and strengthen quality inspection measures. In addition, technical transformation should be integrated closely with enterprise integration and reorganization. We should observe the principles of specialized production and cooperation and cannot again engage in "all-round" transformations that merely fill gaps. There should be fewer investments, more outputs and greater benefits.

The Seventh 5-Year Plan is a key 5 years for the petroleum equipment manufacturing industry. Only by laying a good foundation, raising levels and providing good user services can a greater contribution be made to construction in the petroleum industry.

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PROPOSALS REGARDING DEVELOPMENT OF PETROCHEMICAL INDUSTRY

40130008 Beijing SHIYOU HUAGONG [PETROCHEMICAL INDUSTRY] in Chinese Vol 16, No 6, June 87 pp 446-448

[Article by Zhao Zongyu [6392 1350 3603] of the Institute of Petrochemical Sciences, Beijing: "Some Proposals Concerning the Development of China's Petrochemical Industry"]

[Text] The chemical industry in the industrially developed nations has grown at a rate roughly double that of industry as a whole. Although the rate of growth in the chemical industry in the United States has slowed since the 1970's because of the effects of two energy crises, it still is the highest among all industries. The rate for ethylene, for example, has dropped from 11 to 15 percent down to 5 to 7 percent over the past decades and more, but it still is more than double the 3 percent rate of growth for industry as a whole. The world petrochemical industry also has seen stable growth in recent years and is expanding at an extremely fast rate in developing countries, particularly the oil producing states. To avoid the risk of major rises and falls in economic development, it is best to seek truth from facts and stabilize the industrial growth rate at 7.5 percent. Given that the petrochemical industry plays a key and pivotal role in the four modernization drive, China could consider faster efforts to move it ahead of schedule, particularly through accelerated construction of key petrochemical industry enterprises. Some have suggested that the growth rate in China's ethylene industry must exceed 9.5 percent if needs are to be met. The author offers some views below based on his understanding and consideration of issues in technical and economic reform and development of the petrochemical industry.

1. China should work faster to increase manpower, financial and materials inputs and increase output of petrochemical industry products to lay a modern foundation for comprehensive technical and economic reforms. The world's petrochemical industry now is recovering gradually and the developing nations, mainly the oil producing nations, are developing even more quickly. China is engaged in the four modernizations drive, but primary petrochemical industry products, key links to the people's livelihood and industry, are growing at only 1 to 3 percent. We are importing tens of thousands of tons of petrochemical industry products each year at a cost of more than 1 billion yuan, and the figure is growing.

At present, only about 4 percent of China's crude oil is used in the chemical industry, considerably less than the 8 to 12 percent level in developed

nations. The amount of heavy oil and crude oil burned in China's industrial boilers is seven times the amount of oil used in the petrochemical industry. although great efforts will be made to reduce the burning of oil to four or five times the amount of oil used in the petrochemical industry by 1990, we should strive in every possible way to correct this distributional relationship which reverses orders of importance. Since it would only require the determination to do so, one definite possibility is to save as much of this limited and valuable petroleum as possible and use it in the petrochemical industry for the national economy and people's livelihood by gaining greater technical and economic benefits.

2. To increase the amount of top quality raw materials in the petrochemical industry, corresponding readjustments of technical conditions in the oil refining industry are needed to satisfy demand for light and superior quality raw materials in the petrochemical industry. For example, the output rate is only 45 percent in China for the raw materials suitable for cracking to make ethylene-gasoline fraction oil, naptha and light diesel oil fraction. This figure is 69 percent in the United States, 62.6 percent in West Germany, 57.5 percent in England and 58.3 percent in France. There is a difference of about 24 percent between China and the United States (the focus of Japan's oil refining industry is on supplies of inexpensive fuel oil, so its light oil ration is only 43.8 percent, less than in China.) In addition, thermal process cracking dominates China's oil refining industry, so incomplete technologies are used and internal combustion fuels still cannot meet superior quality requirements. Determination to reform is essential, and China must strive to increase the production rate of superior quality light oil suitable for use as a raw material in the chemical industry from the present 45 percent to about 70 percent, and petroleum products used in internal combustion engines should meet the required levels in international markets. This is something that China can achieve with existing oil refining experience and standards.

3. Adopt the necessary and advanced energy conservation technologies to cut energy losses in the petrochemical industry and use them as raw materials in the petrochemical industry. This could greatly reduce costs, increase competitive abilities and make up for raw materials shortages. Current petroleum refining and petrochemical industry production technologies mainly employ thermal processing or catalytic thermal processing procedures which consume too much energy. Moreover, the energy sources are valuable petroleum, natural gas and cracking gas. The amount of energy consumed in oil refineries and petrochemical industry plants exceeds 14 tons of standard coal per 10,000 yuan in value of output, 70 percent higher than the average amount of 8.15 tons consumer per 10,000 yuan in value of output for industry as a whole. China's oil refineries and petrochemical industry plants consume more than 10 million tons of standard coal each year, so the importance of energy conservation is apparent. Petroleum and petrochemical industry enterprises have been concerned with energy conservation and most attention had been paid to the usual energy conservation measures including heat conservation and energy level conservation.

It is hoped that units with the proper conditions will look into the industrial energy conservation measures outlined below.

(1) Strengthened management and stabilized optimal operations are the greatest energy conservers; (2) strictly control excess air coefficients of all types of industrial heating furnaces to reduce losses from discharges and incomplete combustion; (3) Strictly insulate equipment and pipelines and eliminate leaks; (4)utilize surplus heat and pressure, especially for efficient energy level utilization like low-grade surplus head and pressure for heating, energy and electricity utilization, and adopt "heat pipes," "heat pumps" and other measures; (5) Adopt energy-saving technologies, equipment and catalysts(the integrated combustion and steam cycle high efficiency compressors used in Japanese ethylene cracking facilities reduced total energy consumption from 20.9 to 25.1 megajoules per 1,000 grams of ethylene to 16.7 megajoules,while total energy consumption per 1,000 grams of ethylene in China is about 29.3 to 37.7 megajoules and the figure in sand ovens is as high as 100.5 megajoules); (6) Make great efforts to develop energy-saving machinery and power equipment lubricants, since energy conservation can reach 20 to 30 percent; (7) Transform heating technologies and strive to improve fuels and combustion efficiency; (8) Although larger initial investments are required to substitute coal for oil and save petroleum energy resources to make high grade products (the best way to substitute coal for oil is through coal gasification or coal liquification), the advantages are non-selectivity of coal varieties, non-selectivity of distances, significant environmental protection benefits and so on; (9) Utilize new energy resources.

In addition, we also should speed up development of downstream products in the petrochemical industry including production of fined chemical products. Fined chemical industry products make up about 60 percent of total chemical industry product sales in foreign countries. The fine petroleum chemical industry not only can multiply the economic benefits of petroleum raw materials 10-fold but also is of extremely great significance for technical progress in all industrial sectors, including additives, auxiliaries and son on. Top quality additives and auxiliaries are essential for development of engineering materials.

4. Work as quickly as possible to adopt ready-made and easy-to-use Chinese and foreign scientific research achievements and new and advanced techniques to transform traditional technologies and aging "new equipment" in refineries and petrochemical industry enterprises to exploit existing enterprise potential and carry out transformations, and expand product demand. Examples include heavy oil processing technologies like thermal cracking, adhesion reduction, coding extraction and so on. They should be replaced by intensive hydrogen cracking, moderate hydrogen cracking two-stage catalytic cracking and new types of supercritical extraction to improve the quality of petroleum and petrochemical industry products and achieve integration and intensive development of the petroleum, chemical and fiber [industries] and improve economic results. Foreign countries see technical transformation of old equipment as a primary direction for future petrochemical industry development.

5. China not only must speed up construction of basic industries in the petrochemical industry like ethylene and methanol, but also should accelerate use of underutilized sideline products in existing petroleum and petrochemical industry enterprises like methane hydrogen fractions, ethane, propylene, C4 and C5 fractions. After dual or triple processing, they can be utilized completely and their development should be speeded up in a planned manner, doing the easy ones first and the hard ones later on the basis of market demand and economic possibilities. At present, some units have undertaken or now are developing horizontal relationships in this area, and this should be extended.

6. Take note of biochemical engineering research and development, substitute enzymatic for conventional catalytic production of petrochemical industry products.

In the beginning, petrochemical industry products also were fermented through enzyme chemistry processes. Developments in biochemical engineering may lead to revolutionary reform in petrochemical industry equipment, energy sources and technology. This makes research on biochemical engineering the greatest motive force behind faster development of the petrochemical industry, and biochemical engineering should become the focus of future scientific and technological development.

7. Make planned preparations for the development of petroleum and petrochemical industry substitute product industries in favorable regions. Because continual growth in demand for petroleum and natural gas has made it impossible to satisfy the fast-growing demand fora petroleum products and petrochemical industry raw materials, petroleum substitute product industries and petrochemical substitute products now are emerging (including industries like gasification, liquification, intermediate liquification, synthetic gas chemistry, methanol chemistry,carbon one chemistry and others that use coal or shale oil as raw materials). Inadequate supplies of petroleum and natural gas also have encouraged development of the petroleum substitute product industry in petroleum-short, coal-rich regions like Maoming and Fushun, Shandong Province's Huangxian County and other are as well as in South Africa, Jordon, Syria, Australia, France and other countries. Moreover, conditions for economic competition exist and have promoted development of these substitute product industries.

Furthermore, the future prospects for the development of an industrialized petroleum industry are varied, so its development must be diversified and its products and raw materials must be diversified as well to assure continued development forward. Examples include West Germany's Ruhr region and South Africa's (Sasuoer) region, where sustained development has depended on product and raw materials diversification. Thus, China cannot be satisfied with petrochemical industry products but also must achieve production and raw materials diversification before development can be accelerated. Recently, some foreign countries have made carbon one synthetic chemistry one of the primary directions for future development of technology in the petrochemical industry, which is something that China should take into consideration.

8. Make great efforts to extend computer and microcomputer applications in the petrochemical industry (including medium and small enterprises), use the small scale and flexibility of medium and small enterprise equipment, transform easy advantages and utilize computers or microcomputers for network process control, dynamic monitoring, signal feedback, automatic monitoring and control and other management and control procedures to disseminate technical information quickly, optimize production technology and operations, and continually improve the economic results of equipment and facilities technologies to reach or surpass the competitive levels of large enterprises.

9. Reinforce control over environmental pollution and assure that chemical and petrochemical production does not pollute the environment or affect ecological balances. Construction of modern material s civilization is tied closely to the ecological environment, so environmental protection work must be done well to avert possible problems. Otherwise, ecological balances will be damaged and inestimable dangers will be posed for the people's livelihood and labor environment. It must be acknowledged that pre-pollution prevention is many times [cheaper] than the economic cost of post-pollution cleanup and that there is no way to estimate post-pollution dangers.

All enterprises now have rather complete equipment and facilities for processing contaminated water, including two-stage processing and post-processing, and work now is underway to control atmospheric pollution. Our understanding of permanently-contaminating solid waste pollutants is inadequate and handling of the pollution they cause must be reinforced.

10. The carbon available for human use accounts for less than 2/10,000ths of the Earth's mantle, and the amount is even smaller after inorganic carbonated compounds are subtracted. In future geologic eras, this carbon mainly will be needed to supply the petrochemical industry with the needed raw materials for human clothing, food, housing and activities, and there is no way to make up for the loss and waste for burning carbon-bearing materials. Thus, petroleum, coal, natural gas and other carboniferous materials must be used to the greatest possible extent, and we also do should think of ways to utilize non-mineral renewable energy resources like additional substitution of nuclear energy, solar energy, hydraulic energy and geothermal energy. Some of the most urgent tasks facing everyone in China and especially workers in the petrochemical industry are to expand gasification and liquification of China's substantial coal reserves and abundant shale oil resources, and to develop nuclear power stations as quickly as possible to replace costly petroleum, natural gas and other superior raw materials for the petrochemical industry.

Recently the Federal Republic of Germany's BBC Company has extended its patented technologies for high temperature gas-cooled reactors, and it has been said that the temperature of a high temperature gas-cooled reactor can reach 960 degrees C. this is a good source of heat for the petrochemical industry and can save large amounts of energy. Moreover, the gas-cooled reactors are helium-cooled and involve no radioactive contamination or risk. The applied value of these technologies should be given attention.

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'OCEAN OF GAS' DISCOVERED IN NORTHERN SHAANXI

Beijing RENMIN RIBAO in Chinese 11 Nov 87 p 1

[Text] To its 'ocean of coal', Shaanxi Province has now added an 'ocean of gas.' After 2 years' exploration, geological workers at the Changqing oil field have discovered an underground ocean of gas in the Yulin and Yan'an regions in northern Shaanxi.

Since 1985, workers in the Changqing oil field in northern Shaanxi have drilled 14 wells at Zizhou, Mizhi, Suide, Jia Xian, Qingjian, and Yulin. These wells were sunk in four different gas-bearing strata and every well struck gas. One exploratory well drilled on the Dali He near the city of Zizhou produces some 40,000 cubic meters of natural gas a day. A well sunk at Mizhi produces 100,000 cubic meters of gas daily. On the basis of large-scale on-the-spot drilling and surveys, oil field geological workers have confirmed abundant natural gas reserves in a vast area stretching from the south at Wangjiaping in Ganquan and Zhiluozhen in Fu Xian in the Yan'an region north to the Yulin region tentatively estimated to hold long-range reserves of 85.6 billion cubic meters of natural gas. Of this, approximately 3.3 billion cubic meters are in the Yan'an region and more than 80 billion cubic meters are in the Yulin region. The discovery of the "ocean of gas" will open new paths for the economic development of northern Shaanxi Province.

CSO: 4013/0019

BRIEFS

PRODUCTION FIGURES SHOW INCREASE--Beijing, XINHUA, 15 Nov--The Ministry of Petroleum Industry today reported that as of early November, China had produced 114.7438 million tons of crude oil. This represents 86 percent of the year's plan and an increase of 2.92 percent over the same period in 1986. Also as of early November, China had produced a total of 11.904 billion cubic meters of natural gas, or 91.57 percent of the year's plan. This represents an increase of 284 million cubic meters over the same period of last year. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 16 Nov 97 p 1]

CSO: 4013/0018

BRIEFS

SHANDONG TIDAL POWER STATION--Recently, the No. 5 and No. 6 generators of the Rushan Baishakou tidal power station in Shandong Province--China's first tidal power station--went into operation, bringing the total installed capacity of the station to 960 kilowatts. The power station has a total of six generators. The first and second/third and fourth generators went into operation in July 1978 and April 1983 respectively. They have already generated some 5.6 million kilowatt-hours of electricity. With the fifth and sixth generators now on stream, the station will have a yearly output of 2.32 million kilowatt-hours. [Text] [Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 11 Nov 87 p 1]

CSO: 4013/0017

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